R/E RESEARCH & ENGINEERING

FOR RESEARCH & DEVELOPMENT MANAGERS

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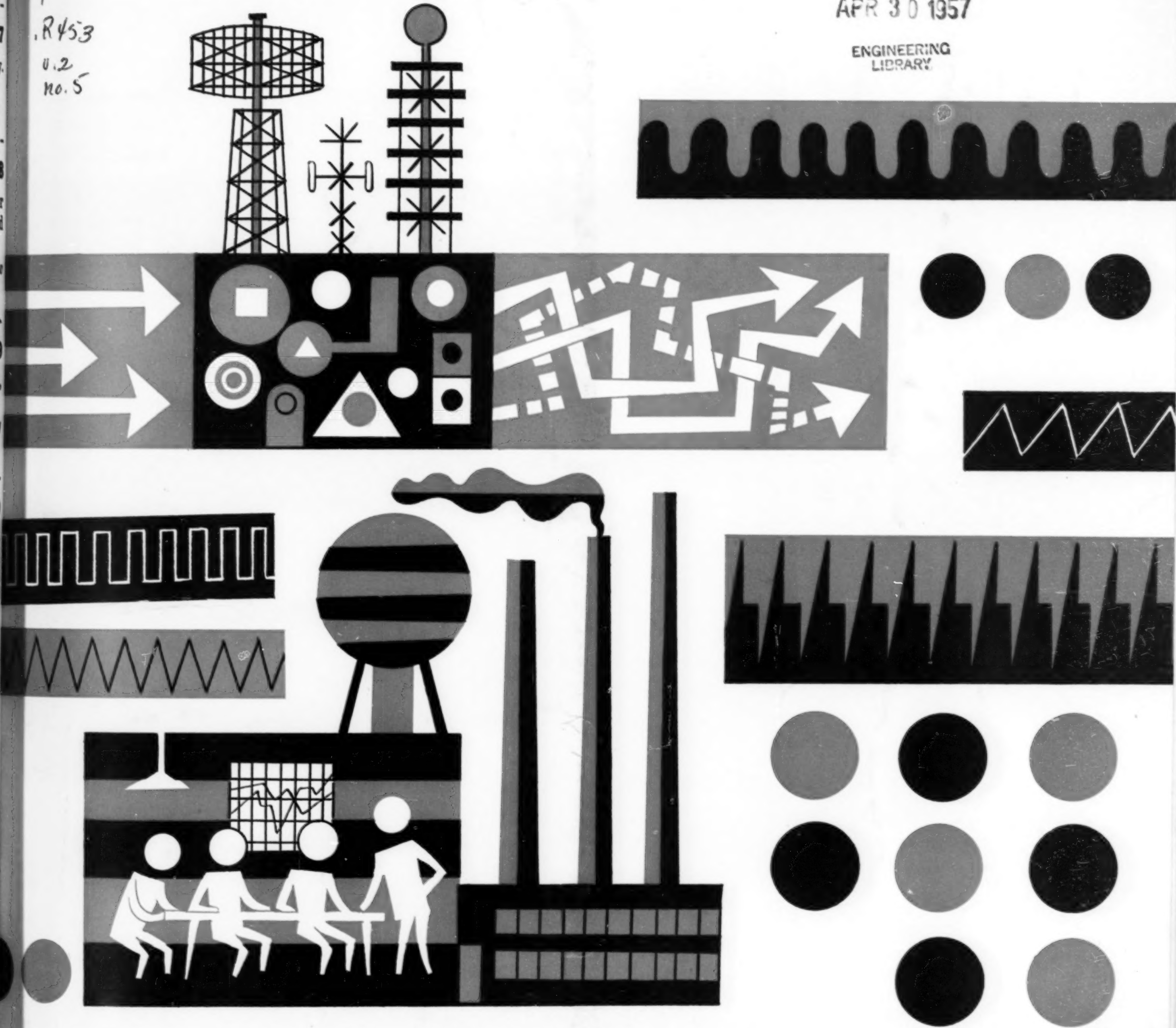

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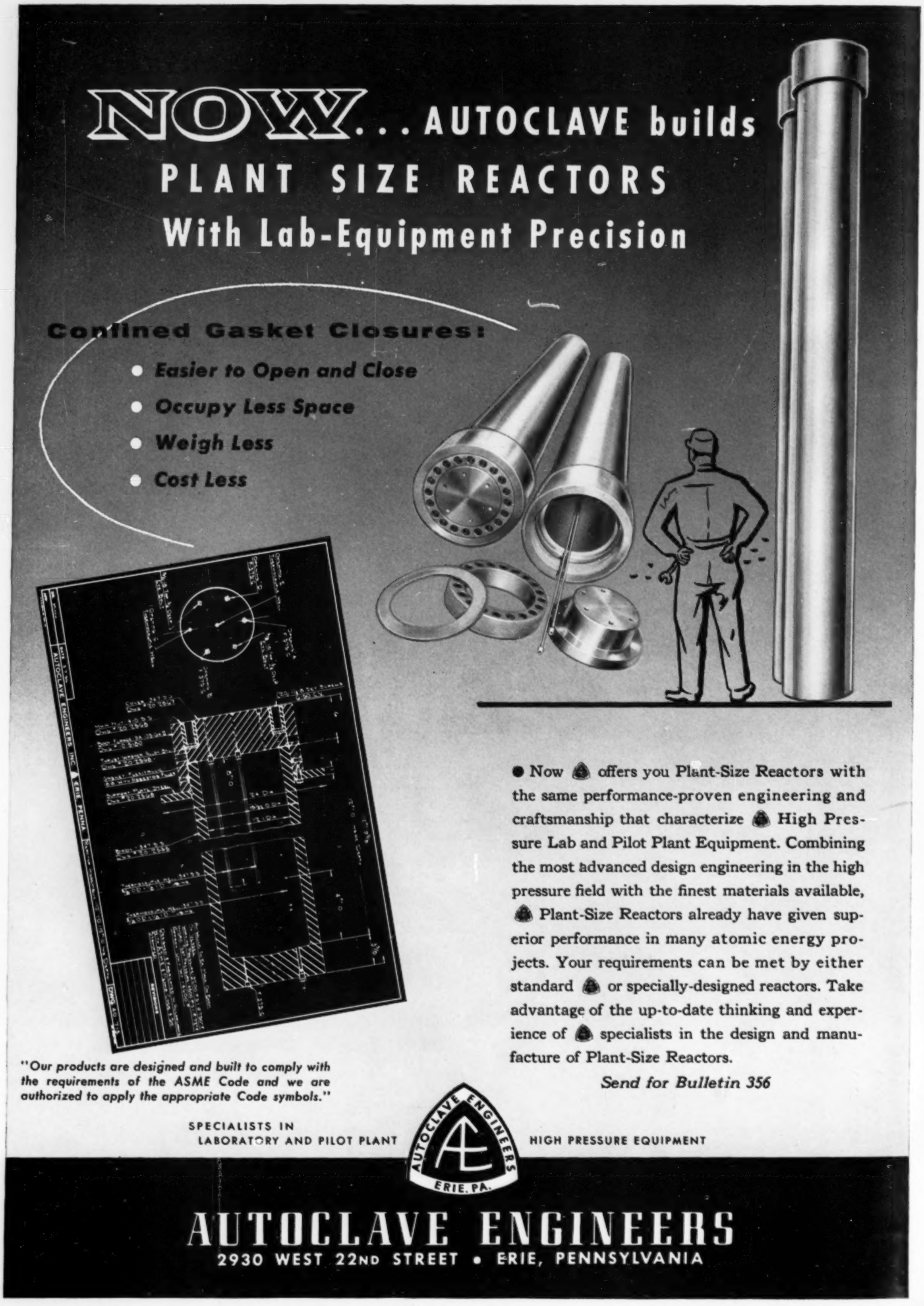

FOR MORE INFORMATION CIRCLE 1 ON PAGE 48

MAY 1956
VOL. II NO. 5

RESEARCH & ENGINEERING

THE MAGAZINE FOR RESEARCH AND DEVELOPMENT MANAGERS

FEATURES

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Letters

Inspection Method Sought

Hastings, Mich.

The article "Radioisotopes", page 22, January 1956, section on Radiography states that radiography cameras are commercially available. We are in search of a method of inspecting piston rings by radiography. Any information you can give us will be greatly appreciated by our engineering department.

PAUL R. BISHOP
Industrial Engineer

HASTINGS MFG. CO.

(Editor's Note: If you have information of interest to Mr. Bishop, write him at above address, or send your suggestions to us and we will forward them.)

Research Secretaries Talk Up

Detroit, Mich.

I am a secretary in research and read your articles concerning administration in hope of finding good points which are particularly applicable to our company to drive home to my boss. Here are some problems I wish you would hammer at from all angles: (1) How to sell spending for research and future projects as against current engineering and production. (2) The importance of picking research supervisors who can administer, not just follow orders. (3) Picking supervisors who are imaginative thinkers and can encourage others to create. (4) Managing research so that the utmost responsibility is put on the shoulders of supervisors, relieving over-all managers free of most detail to plan the future.

MISS ANNE BOSSLER
Secretary

STUDEBAKER-PACKARD CORP.

Indianapolis, Ind.

May I please have a copy of your fine article *Time Management for the Research Executive* which appears in your February 1956 issue?

This is a valuable article for any executive, but I am interested in it particularly from a secretary's point of view. It is certainly a pleasure to see in print some of the ideas which I have tried for years to impress upon various bosses (not always my own). Fortunately, my present boss keeps my thinking powers employed to the utmost. However, I have had jobs, and I know many secretaries who have such jobs now, where the employer actually tries to do his own secretarial work and use his secretary as a stenographer only. With the present high pay and shortage of secretaries why can't employers be given more instructions on how to use a secretary?

The article would be valuable to me to keep permanently, with the suggested redpencilling, to thrust in front of some hurried, harried executives who spend half of their time doing "busy" work while their secretaries sit around and read magazines or manicure their nails although they are capable of and willing to do a great deal more work.

MRS. HARRIETT MOISTNER
Secretary to the Chief Engineer

LINK-BELT COMPANY

Valuable Article

Army Chemical Center, Md.

Thank you for your permission to reproduce and distribute to the executives of the Command your article. "The DP Problem". From a variety of professional articles reviewed each month, a particular one is chosen as a pertinent means of improving executive management. Since our organization is composed for the most part of highly qualified technical and scientific personnel, we have several personnel problems similar to those outlined in your article. It should be of great assistance to myself and key Directors in management and administration.

WILLIAM H. ALLEN, JR.
Colonel, CmlC, Commanding

CHEMICAL CORPS ENGINEERING COMMAND

Good Size

Pittsburgh, Pa.

I want to congratulate you for the excellence of RESEARCH & ENGINEERING, and hope you can keep it successful without giving us a book half an inch thick, which will be so formidable in size that the busy people you are trying to reach will by-pass it.

Particularly I would like to single out Merritt Williamson's department for an inspired approach to the basic problems of research administration. His material makes good reading and I have a hunch he's having a lot of fun doing it . . . can hardly wait for the next issue to see how the experts respond to the managerial problems he presents . . .

R. E. BIRCH
Director of Research

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The DP Problem

Poughkeepsie, N.

Mr. Luis J. A. Villalon
Management Affairs Editor

When I first came across your article, "T DP Problem", in the March issue, I ca gorized it as sensationalism, along with ma of today's news. However, as I read on, opinion changed. I have two comments: (in the profession, there are many hig skilled individuals, plus a few genii—so tend to be problem children. This is true only in engineering but in all other profe sions, so in justice "the problem child abound in greater number" is not applica to the technical and scientific group; (2) solution to a specific problem relies on g common sense which is well stated in yo conclusion. However, if each person is eval ated and treated as an individual, the D problem would never exist. Every man has basically good nature. Let us deal with better part of the individual.

EARL P. PURPURA
Project Engineer

DAYSTROM ELECTRIC Co

We're Way Ahead of 'Em

Cleveland, O

We noted your comments regarding the p letizing of fly ash in England for use in ma ing building blocks on page 14, January 19 issue.

Research work going back several years the Dwight-Lloyd Research Laboratories h produced both sintering and pelletizing me ods of utilizing fly ash as a fully fired lig weight aggregate for either building blo and the like or monolithic concrete.

HAROLD E. ROWEN
General Manager

DWIGHT-LLOYD D
MCDOWELL CO., I

Keep Us Informed

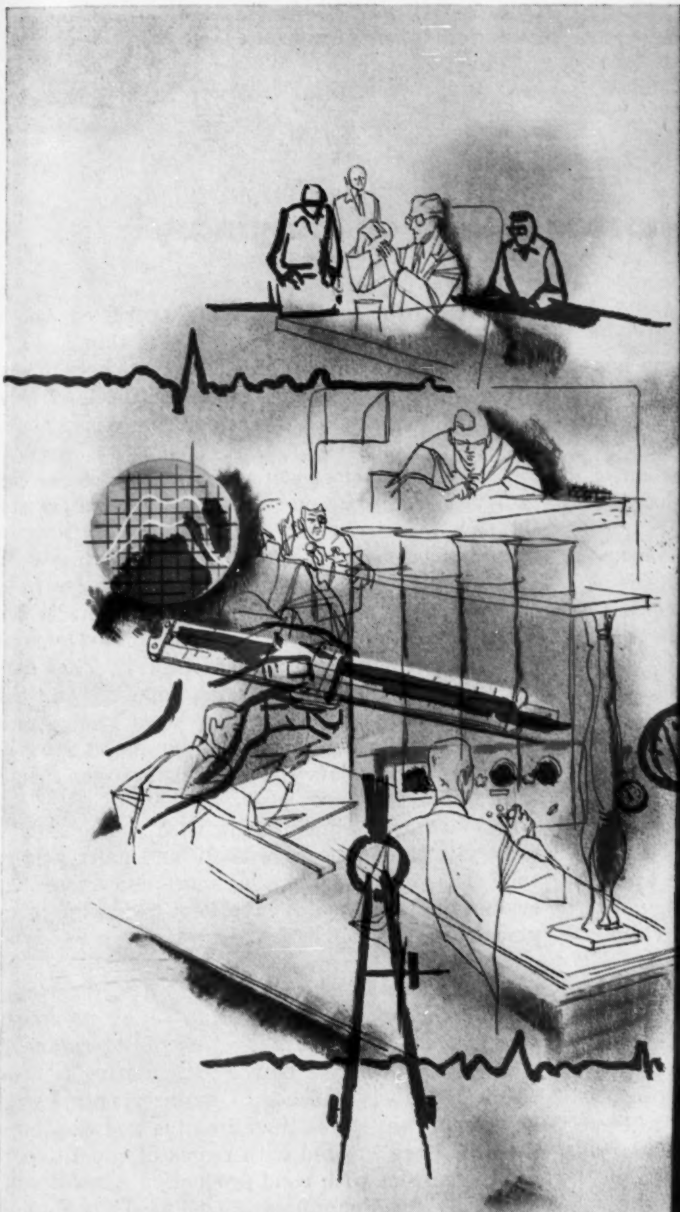
East Aurora, N.

I have not received a copy of R/E si changing jobs and would like very much have my subscription continued. I have n noticed any copies here and believe th should be at least one copy circulated throu the engineering and management personn

STEPHEN A. MURTAUGH, JR.
Systems Engineer

MOOG VALVE COMPANY, I

If subscribers will drop us a card giving b old address and new, we can keep subscr tions up to date—Ed.



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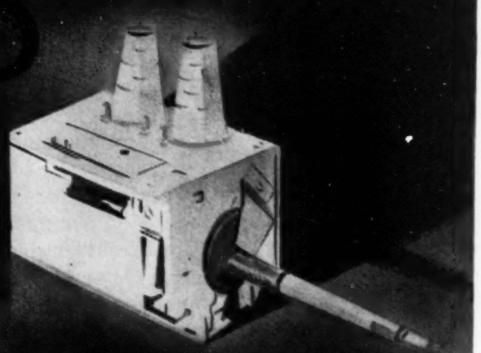

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FOR MORE INFORMATION CIRCLE 2 ON PAGE 48.

RE Marks

The Engineering Shortage: Real or Imaginary?

Much has been written and said about a current and future shortage of engineers and scientists in this country. But not much has been official. By the time this issue has gone to press, the first official hearing on this matter will have started (scheduled to begin during the week of April 16). The Congressional Joint Committee on Atomic Energy, a committee that could do something about the problem if it does exist, will be listening to approximately 40 leading scientists, engineers and educators.

We hope that some of the experts who appear at the hearing will represent the middle group of engineers and scientists, the men with 10 or more years of experience who have not yet and may never cross over to management in authority, responsibility and compensation. Discussions with the more mature, technically competent men in this group yields a picture quite different from that currently presented in the nation's press. And the picture is one that is essentially organized around a core of readily voiced economic complaints.

Most of these men do not believe there is a shortage of engineers—just a shortage of decent paying jobs. Nevertheless, the law of supply and demand appears to be working since starting salaries for the beginning engineer vary from $350 to $475 and even go up to $535 per month (highest amount reported to us) for the bright engineer in the top 10 percent of a five year course. Those with two, three and four years of experience can manage to get into the $500 to $625 or $650 per month range, but the going begins to get rough at about $700 per month. In spite of apparently pressing needs, engineers without the proper background—usually some specialty training of use to the hiring company—will be turned away if their asking salary is $700 per month or higher.

Most of the men will admit there is a shortage at the other end of the scale: men with advanced degrees, superb and proven technical competency, business management know-how, and development and design administration sense. The total number of jobs available for these men is significantly less, but still the shortage exists even though starting salaries vary from $18,000 to $30,000 per year coupled to the numerous side benefits usually offered management. The reasons are obvious. Universities are still not set up to give a man the technical training for an MS or PhD and include courses in engineering management and administration. Engineers and scientists who have made the grade in this classification got there on their own, in the main. However, some universities and industrial companies have recognized this problem and have organized special courses to alleviate the situation.

But most of the men emphasize that there is not a shortage of engineers particularly in the middle range representing the great mass of technically trained manpower—the men with 10 or more years of experience who are not in the management rank. To them, the shortage of engineers is as real as classifying an engineer as part of management without giving him the responsibilities and privileges accorded management. Here are some of their attitudes:

You're a sucker if you've been on a job for more than a year and are not actively shopping around for more money. Only by this technique can you advance your salary or keep ahead, percentage wise, with starting rates for engineers and comparable industry increases in other non-engineering fields. This attitude is undoubtedly generated by antiquated salary review systems, or systems that some are good but are not administered properly. They feel that they can only beat the system by job hopping. And they cite the fact that some companies have hired graduates at salaries higher than those paid starting engineers recruited several years ago; and salary differentials between men hired with several years of experience—the job hoppers who learned early—are not commensurate with the contribution of the more mature engineers with 10 and more years of experience. The result: a turnover more expensive than a salary evaluation that would have kept older, more mature engineers on the job.

An engineer in a primary field of engineering—research, development, design and testing—is in no sense a part of management unless he is working for a small company. Men who feel this way deride the "stimulating", "creative", and "exciting" labels attached to engineering and scientific jobs. For them, the stimulating, creative and exciting aspects of their jobs are covered with reams of repetitive, routine details consistent with rigid production schedules of factories. Most agree that engineering jobs need the kind of definition that will permit individuals to work more at the professional level and less at the high class technician level.

Ask any competent engineer over 45 whether he thinks there's an engineering shortage. Some often can only get jobs if they are willing to accept salaries offered to men with much less experience. And some large companies won't touch them except at ridiculous salaries. Many engineers in this classification are quite bitter. They are men who received degrees in the thirties, started at salaries of $1[illegible] per month, reached $400 to $500 per month in the late forties and then coasted with small raises into the early fifties. By the time they had rationalized themselves out of company loyalties and made the emotional adjustments necessary for $2000 to $3000 cars, $17,000 to $25,000 houses and $2000 per year expenses for sons and daughters in college, it was somewhat late. Few personnel men offer an engineer $3000 to $4000 per year more than he is getting

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2-NITROPROPANE
$CH_3CHNO_2CH_3$

2-AMINO-2-METHYL-1-PROPANOL
$CH_3C(CH_3)NH_2CH_2OH$

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FOR MORE INFORMATION CIRCLE 3 ON PAGE 48

If you can sell engineering ideas to management, you're better off as a salesman selling an engineered product—get out of the primary field. The profession is still geared to the belief that the men who sell the product are worth two and three times the men who dream the ideas up and develop them to the marketable stage. Men with this attitude cite patent agreements and bonus arrangements out of phase with the contribution of the product to the welfare of the company particularly when compared to sales staff remunerations. Tied in is the comparative ease with which sales engineers can attend shows, conferences and engineering meetings on expense accounts.

The professional societies that insist on an aloof attitude with respect to salaries are encouraging the growth of engineering unions. We have had a shortage of MD's longer than we have had an alleged shortage of engineers. But you don't hear the American Medical Association clamoring for more students to enter medical colleges. The major contention of those holding this belief is that the AMA acts more like a union in protecting against an oversupply of doctors while the engineering societies are barrelling along a road which may make engineers available at salaries that do not warrant an investment of five to seven years and $10,000 to $15,000. Most of them remember the engineering shortage during 1941 to 1945 and a definite oversupply just before the Korean War. About this time a government study indicated an adequate supply of engineers and the possibility of an oversupply at the rate at which we were then turning out graduate engineers. This report has received some severe criticism in the past few years. But engineers looking for jobs just prior to the Korean War find it difficult to believe that if we proceed with a program to turn out 35,000 engineers per year we shall not produce a pre-Korean situation within the next five years.

There is no real shortage of engineering manpower in this country. We would have more engineers than we could use if only 60 percent of the engineering graduates in the past 20 years were still working in the primary field of engineering. To back this point up, men point out that there is always a shortage of "cheap" labor in every field not protected by rigid government minimum wage laws or union agreements. The garage mechanic with three and four years of experience can perform 75 or 80 percent of the work performed by a mechanic with 15 or 20 years of experience. But the older man has usually more financial responsibility than the younger man and cannot work for as low a salary. The same situation is true with respect to a number of stanard routine engineering jobs. Again as proof, these men offer numerous instances in which older experienced men were replaced by younger men at lower salaries. In addition, a significant percentage of the more experienced men find themselves drawn to the field of administration or sales because of greater financial rewards. Some companies have made an earnest effort to correct this situation by equating senior engineering jobs with administrative functions at equivalent salary scales. But evidently this trend has not caught on fast; it undoubtedly will do so in the future.

The government's attitude towards engineers in industry and engineers studying at graduate schools has been pretty much snafued. Not enough attention was paid to inducting these men into Army or Navy installations where they could use their engineering know-how and thus maintain their engineering status. Up until about two and one-half years ago this belief was certainly valid but since that time, some efforts to correct this situation have been fruitful. According to the Engineering and Scientific Manpower Commission, it was quite a struggle to gain official recognition of this problem. Men engaged in defense-supporting industries were quickly inducted with little regard to industry's need for their services. Students who had been deferred for graduate work in science lost their temporary immunity, and their training was arbitrarily interrupted in mid-career by induction into the armed services. Public Law 305 now incorporates provisions that make wiser utilization of scientists and engineers, but it will still take some time to correct impressions generated by years of abuse.

These then are some of the attitudes that should be put before the Committee for evaluation. Certainly some or all may be classified as the normal type of gripe that occurs in any organization of men and at the most represents only a small fraction of the total employed in the field. But attempts to shrug off or gloss over these points would constitute an unhealthy approach to the evaluation of our engineering manpower resources and needs. Statistically too many engineers are voicing these opinions.

Last year D. G. Moore and R. Renck of the University of Chicago reported the results of a study that found that engineers and scientists are chronically frustrated and unhappy professionals who like their work, feel it important but are dissatisfied with the recognition and reward they receive. According to the "small sample" measurements on which our comments are based, Moore and Renck came up with a reliable and valid study.

Certainly, the major problem of attracting men to work in the primary fields of engineering and science and then holding them there is not at all 100 percent economic. But the overall trend toward higher and higher costs for the every day necessities has emphasized take-home pay to the point where it has become a primary issue.

The engineering manpower situation is related to the current teaching situation. There are still those who claim, "We do not have enough good engineering teachers". We do. The trouble is that most of them cannot afford the luxury of academic life; they are working in industry for two or three times the salary they can pull as teachers. The entire teaching problem could easily be solved by an across the board raise of 25 to 50 percent. Expensive? Yes. Reasonable? Yes. Impossible? No. Not if the same energies went into increasing instructors' and professors' salaries that go into expanding physical plants on the campus. In the long run, it will be cheaper to subject our future engineers to good engineers and scientists than to expose them to poor instructors who communicate by "transferring statements from their notebooks to the notebooks of the students without having the contents pass through the heads of either".

Our engineering manpower problems may be in a comparable situation. We do not know. Information of this type can only be obtained by setting up and applying a valid and reliable national and industry wide survey. Interviewing the experts is a good starting point. But if no expert has carried out an authoritative survey, we hope the committee will. Then and only then will we know whether the engineering shortage, current and projected, is real or imaginary.

Harold G. Buchbinder

EDITOR

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FOR MORE INFORMATION CIRCLE 4 ON PAGE 48

Developments

Research and Development: Report from Britain

Research and development in Britain is proceeding at a vigorous pace. If the detailed report *R/E* received a few days ago from London is any indication, British firms in all fields are quick to see the possibilities of new products and processes and to capitalize on them by extensive use of their own R & D facilities.

As in the U. S., the R & D department seems to have become the focal point of many companies. One of the reasons for Britain's remarkable recovery from near bankruptcy in the post-war years is undoubtedly the resourcefulness of its R & D people. To top British leaders it is clear that a concerted attack on the frontiers of technical knowledge is one way to overcome the insular weakness of a nation shorn of many of her colonial possessions. In short, the Commonwealth must continue to emphasize technological development if it is to retain its role in world affairs. Some areas of British R & D are briefly described below.

Titanium

As everybody knows titanium is difficult to produce and much still remains to be learned about its fabrication. To combat the current high price of the raw metal, Imperial Chemical Industries, Ltd., has developed a new process for producing titanium that uses sodium rather than magnesium to reduce titanium tetrachloride. One of the difficulties with the older process is the removal of magnesium chloride from the metal. Despite the opinion of some authorities that sodium reduction would be commercially unfeasible, the research team at the General Chemicals Division of I.C.I. decided to go ahead with work on it.

Research was begun early in 1951 and first experiments produced seven-pound ingots. Over the next two years the firm built a 100-lb ingot reactor and a 900-lb ingot reactor. Eventually a large commercial titanium plant was built which successfully used the sodium process.

Casting of titanium in 12-inch and 20-inch long ingots, and production of a high-duty alloy suitable for compressor discs on blades has been started by William Jessop & Sons, Ltd. The alloy, sold under the name of "Hylite 50", has creep properties higher than that of other titanium alloys.

At Jessop research on the melting of titanium began in a furnace producing three-pound ingots. This was replaced by a pilot plant capable of melting six-inch diameter ingots weighing up to 40 lbs.

In the large-scale plant that resulted from these studies, and from an exchange of information with a leading titanium producer in the U. S., the consumable electrode, double melting process is used. The melting occurs in vacuo and ingots up to 2000-lb and 20 inches diameter are now being poured.

Parallel with this work on melting, the alloying of titanium was researched. Development work was concentrated on improving the creep strength of alloys at 350 to 400° C. Creep testing rather than stress/rupture testing was found to be of far greater value for evaluating the properties of the alloys.

Continuous Casting of Steel

Continuous casting of steel has received much attention in Britain as well as in this country, since it can mean appreciable reductions in steel-making costs up to the stage of secondary rolling.

One of the major difficulties in developing the process has been the tendency for the ingot skin to rupture in the mold. After deep fundamental studies, particularly on the freezing of the molten metal in the mold, the British Iron and Steel Research Association evolved a spring-mounted mold which, when necessary, moves down with the ingot until the skin has frozen sufficiently. This device proved successful on a laboratory scale.

Since such a new production technique involves fresh problems of plant design, an experimental pilot plant was built in the BISRA laboratories at Sheffield. The process was further developed by the erection of a full-scale experimental production plant which now makes ingots of high-speed tool steel and stainless steels.

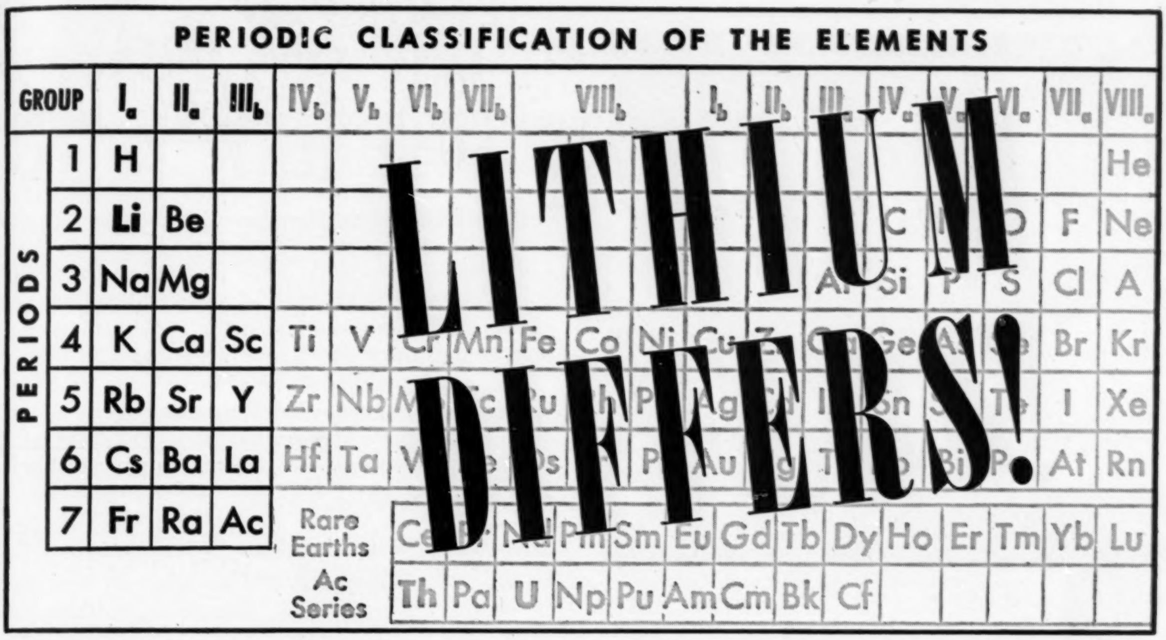
In addition to savings occasioned through by-passing casting into orthodox ingots, reheating these ingots, and primary rollings to reduce the ingots to the size of the continuously cast product, other savings in the new process include improved yield, elimination of scaling losses, and savings due to process flexibility.

Plastic Metal-Forming Dies

Facing of epoxy resin dies with metal, thus giving the tools a longer life than high-carbon steels and making them suitable for high production press work is the latest development of Leicester Lovell & Co., Ltd. According to the firm, considerable savings of time and cost can be achieved.

Leicester Lovell had studied the use of plastics in press tools, but the lead to development of a long-life plastic came from an article in an American trade journal. Cast epoxide resins for press tools were developed and tried by various firms.

The cost of material in large dies made from pure resins is high. Experience gained in the foundry industry with silica sand was used to develop a cheap central core, afterwards faced with the epoxide resin. This filled cast epoxide resin die lasts a long time. For example, a die punched 5000



Lithium, by reason of its atomic configuration and general characteristics, is rightfully included as the first member of Group I in the Periodic Table. A detailed study of the properties and reactions of both the elements and their compounds, however, shows that Lithium often resembles the metals of Groups II and III more closely than Group I. Following are some characteristic differences:

Lithium differs in organic chemistry . . .
because its organolithium compounds form a unique class with stability, solubility and activity characteristics intermediate between those of the Group I and Group II organometallic compounds.

Lithium also differs from the other alkali metals in that it serves as a unique catalyst for the polymerization of diolefins to materials of definite and predictable structure. It directs, for example, the polymerization of isoprene predominantly to 1,4 addition structures.

Again, recent investigations have indicated an interesting potential as a direct reducing agent in solvents such as ammonia, low molecular weight amines, and ethylenediamine.

Lithium differs in metallurgy...
inasmuch as the affinity of Lithium for oxygen, for example, is being utilized to reduce porosity in copper and copper alloy castings. Recent research has revealed that Lithium will produce brazing alloys with self-fluxing properties and increase the wetting ability of these alloys.

Lithium differs in inorganic chemistry . . .
the usefulness of Lithium Hydride and Lithium Aluminum Hydride in the preparation of other hydrides having already been widely demonstrated. Recent studies indicate that other complex hydrides prepared in a similar manner may prove to be interesting tools for research. The low dissociation pressure of Lithium Hydride at its melting point, to cite a specific example, is unique among all hydrides. LiH also has some slight solubility in polar organic compounds which is again unique among alkali metals.

Lithium differs in heat transfer . . .
based on its physical properties it has no equal as a liquid metal coolant. Due to corrosion caused at elevated temperatures by impurities in commercially available Lithium and Lithium Metal, Lithium has thus far found only experimental use.

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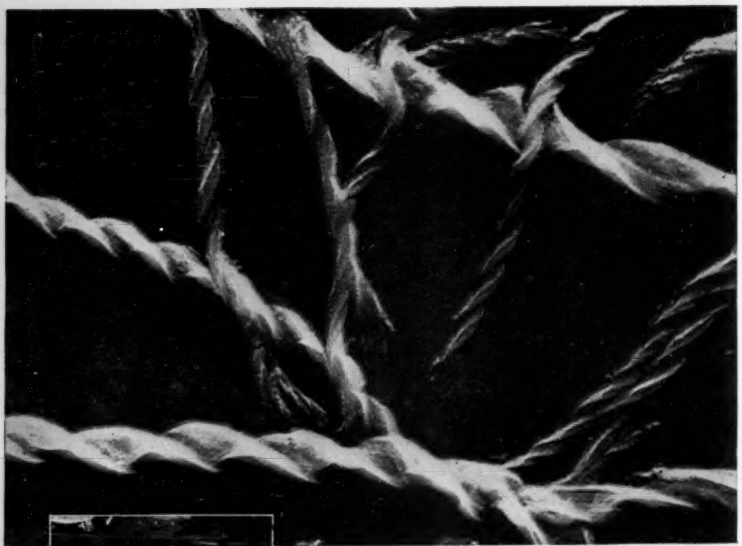

Electron Micrograph showing rope-like structure of lithium stearate.

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Dr. Simard and microscopist.

Basic studies with the RCA Electron Microscope under the immediate supervision of Dr. Roger G. Simard, of The Atlantic Refining Company Research Laboratories, Philadelphia, have brought the grease system into microscopic focus. Today's high-speed precision machinery demands specialized greases that will withstand extremely severe operating conditions. An ordinary lubricating grease is a suspension of metal soap fibres in a lubricating oil. Distributed uniformly throughout the oil, the soap fibres hold the oil between them, principally by capillary attraction. By studying these soaps with the electron microscope, scientists are able to correlate their structure with the physical properties and behavior of the finished grease. Thus, it is possible to screen out defective batches and to set up standards of quality leading to the development of new and better greases.

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Electron Microscopes

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outer door panels in 20-gage mild steel for a popular saloon (sedan) car. A punch, pad and ring made in the resin was compared with various other plastics and with high-carbon steel. The steel die failed after 20,000 pressings while the cast epoxide resin die lasted for 8500. No other plastic die lasted more than about 1000 pressings.

The development of metal-faced cast epoxide dies has changed the picture. With the same type of punch, pad and ring with which high-carbon steel failed at about 20,000 pressings, these new dies showed no appreciable wear after 27,000 pressings.

Aluminum-Tin Bearings

The use of aluminum and its alloys as bearing materials is comparatively recent. The most suitable addition to aluminum to give it bearing qualities is by means of a soft, low-melting point tin. The practical limit in a cast aluminum-tin alloy is below 10 percent of tin, although from the point of view of bearing characteristics the more tin there is in the material the better.

In work sponsored by the Tin Research Institute, it was found that when the tin content of aluminum-tin alloys exceeds about seven percent a continuous film of tin is formed round each aluminum crystal and causes weakening of the bearing. The problem therefore was to find a method of altering the distribution of tin in aluminum-tin alloys from a continuous intergranular film to discontinuous pockets.

It was found that if the aluminum-tin alloy was cold-worked and subsequently heated to a temperature which would cause recrystallization of the cold-worked aluminum the tin films were broken up. This gave a structure which is exceptional as a bearing material. Up to 60 percent tin can be added to the aluminum.

Bronze-Teflon Dry Bearings

It has been evident that a bearing material capable of operating without any liquid lubricant would fulfill a definite need. In addition, such a bearing should be capable of operating in the presence of unconventional liquids. It should also be clean running—an important consideration in the food processing, laundry, textile and paper-working industries.

Glacier Metals, Ltd., undertook the solution of this problem and turned to polytetrafluoroethylene (known as Teflon in this country). As is well known, polytetrafluoroethylene has a very low coefficient of friction and has excellent wear properties. Research at Glacier Metals resulted in incorporation of Teflon into porous bronze with a steel backing.

Tractor with Hydraulic Drive

The Research Station of the National Institute of Agricultural Engineering (N.I.A.E.) has exhibited a test-rig tractor with a hydrostatic transmission. The idea of hydro-

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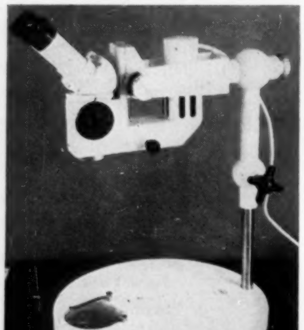

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static transmission is not new. After 50 years of frustration, however, the introduction of synthetic rubber is one of the major reasons why a hydraulic transmission for powered vehicles is now possible.

The research at N.I.A.E. is typical of much that is best in British research—searches through scientific literature, consultation with experts, studies of existing knowledge, practical uses, and the wide variety of adjuncts and accessories. In this event, no deep fundamental research was necessary and the results were achieved by a small team, because existing knowledge was traced and used throughout.

Examples of this search for knowledge are illuminating. The original search through scientific literature and patent applications gave much information. Advice on oil speeds and valve faces was obtained from the Mechanical Engineering Research Laboratory at East Kilbride. The British Hydromechanics Research Association was consulted about seals. A member of the Admiralty Gunnery Establishment was able to recommend a system of boost for the oil pressure, which ensured that the oil in all parts of the circuit was above atmosphere pressure. This avoided backlash or sponginess in the control of movement—a vital point.

During the building of the motors, which are in the wheels, close liaison was maintained with the technical departments of firms supplying mechanical components. An existing hydraulic pump was adapted to provide the power.

Laboratory Glassware

H. J. Elliott, Ltd., has been experimenting for many years to try to avoid the lead fillings in the graduation of volumetric glassware, because of the contamination thus caused to the contents. Efforts were further spurred about two years ago by inquiries about lead traces in some foodstuffs, which were thought to have come from the graduation fillings in pipettes.

A small Research and Development Group was set up by the company in the post-war years to collate the information received from industry when the new designs in traditional laboratory glassware were introduced.

The key to the solution of the problems of lead-free markings was found in a technical journal. When followed up, it was recognized as a possible solution to the problem. In the meantime, a visit to the U. S. by the Managing Director resulted in the accumulation of a considerable amount of unpatented information.

Details of the process are secret, but the researches resulted in the development of a line of graduated glassware without lead contamination.

Other R & D Work in Britain

Other fields of endeavor in which the British are currently engaged include:

• Production of niobium (important for use in atomic energy reactors) both as a metal powder and in tubes and sheets.

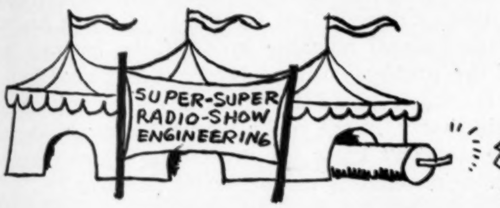
• Use of nylon as an engineering material in conveyor chains, bearings, bushes, gears, union nuts, screws, etc. Advantages of the nylon conveyor include easy cleaning, light weight (one-eighth that of stainless steel resulting in a considerable saving of power), acid-resistant, low coefficient of friction so that lubrication is almost unnecessary, and quiet operation.

• High pressure flexible pipe units to carry different liquids at high pressures and temperatures in the aircraft, chemical, food processing and other industries. New ma-

terials such as polytetrafluoroethylene are being used.

• Development of a process for making very hard anodized surfaces on aluminum for wear resistance. Major problems to be overcome included the cooling of the electrolyte and its rate of agitation, the high current densities and the severe burning of the anode.

Radio-Engineering Show a "Dud"? Is Specialization Breaking It Up?



Is the increasing specialization within the electronics industry killing-off the annual Radio-Engineering Show? More than the blizzard and heavy snow must be considered to account for the decreased attendance at the recent Show in New York. And an informal and very limited survey by R/E has also revealed lowered interest in the Show by engineers attending it. However, most technical sessions were heavily attended, as usual.

Some engineers may not have visited the Show because it was again held at the distant Kingsbridge Armory instead of the new Coliseum. Scheduled to be completed in time for the Show, the massive hall was not opened until late April. We shall have to wait another year and study attendance figures for the 1957 Show at the Coliseum to see if there is a true trend downwards. If there is, it could indicate less interest in the industry wide view and more interest in the specialty conventions, which continue to grow in number and size. Such compartmentalization could lead to many vexing management problems in the technical community.

There is a possibility that the Show will eventually be replaced by a group of smaller shows and conventions—one for each professional group or specialty in the IRE. Signs can be noted in the reexamination of the mission of the *IRE Proceedings* by its Editorial Board. According to the March issue (p. 295), the board members are debating the possibility of publishing all technical papers in the 20-odd transactions of the professional groups, leaving only general association and industry news in the *Proceedings*. A number of these specialized shows and conventions—computer, military electronics, audio, microwave, semiconductor, magnetic amplifier, etc.—are already held.

Job Shopping One Objective

A number of engineers queried by **R/E** admitted that their only reason for attending the Show was to size up the job market and find out how much they are worth. One designer stated that he now only attends the Show every other year because there isn't that much difference from one year to the next. Another says that he is able to keep up with new components by studying the "new products" pages of the technical press. At the same time more and more parts are brought to him for inspection by the increasingly active technical reps.

At the Show a number of new transistorized devices were shown, but the great majority of instruments still use tubes. There are still no transistors in television sets. Perhaps

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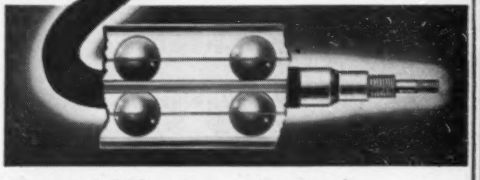
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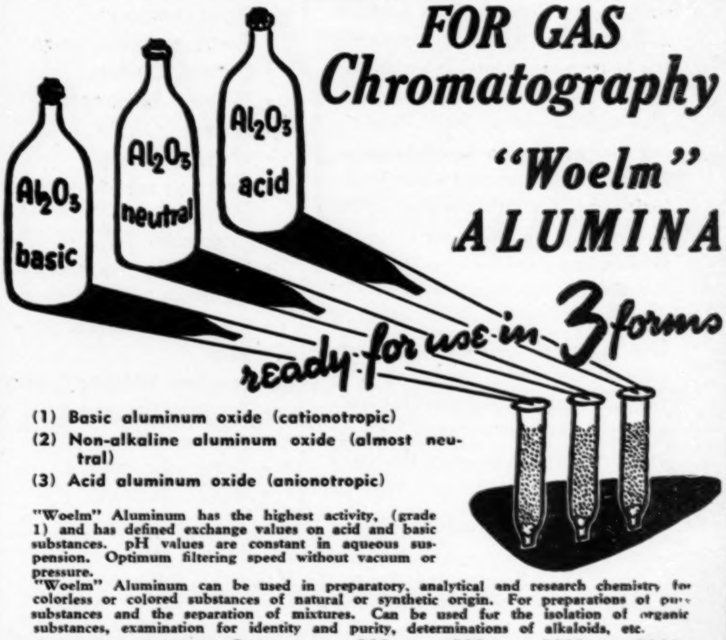

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some portable TV—portable in the sense that it doesn't require a power connection—will be introduced soon with many transistorized circuits. The dollar volume in semiconductor diodes and rectifiers is still greater than that for transistors.

Impact of Computers

One of the liveliest sessions at the convention was a symposium on the impact of computers on science and society. The computer has had a greater effect on physics than business operations, according to R. E. Meagher of the University of Illinois. For the businessman, the computer just does arithmetic, but for the physicist it has become an experimental machine in itself. In business the analysis of the problem is done *before* it is placed in the computer. D. Sayre of IBM supported Meagher's thesis when he said that ". . . the really interesting problems are those where we don't know the procedures". One example he gave was in formulating airport traffic patterns.

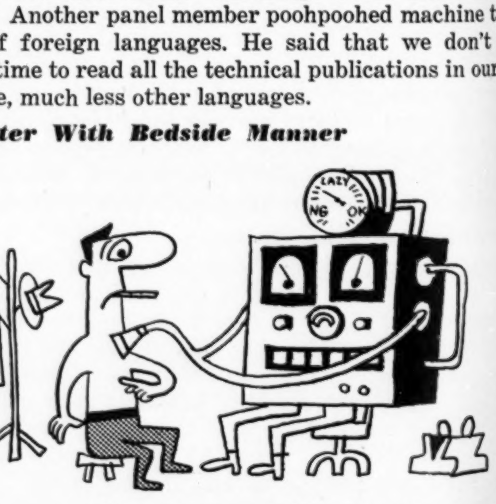
Future Design of Computers

Integration of computers with other machines will be the next big task for computer designers, according to Meagher. He says that many engineers are under the mistaken impression that the only big job remaining is transistorization. Some of the reserve power of computers (they continually run ahead of the programmers) should be used to allow the machines to program themselves. (Some of the latest UNIVAC's do this already.) Sayre forsees the day when programmers will talk instructions into computers in a language close to that used in talking to other programmers about programming. The shortage of programmers received a great deal of attention at the symposium. Dr. Astin, head of NBS, called for intensive training programs. Some of the speakers foresaw the day when programming will be taught in high school like typewriting. One said every college freshman should be given some instruction on computers.

More or Less Patents

There was a difference of opinion among the speakers as to effect of machine searching of patents. One maintained that the computers would throw out more patent applications by making more accurate searches, while another speaker felt that faster searching would lead to more patents. Another panel member poohpoohed machine translation of foreign languages. He said that we don't have enough time to read all the technical publications in our own language, much less other languages.

Computer With Bedside Manner



Another unusual computer application was proposed at the symposium on medical electronics. Dr. V. K. Zworykin of RCA foresaw a computer that remembers the patient's

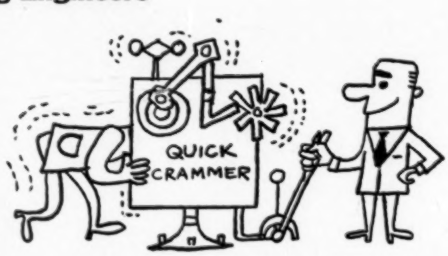
condition for a number of years back. When the patient's blood pressure, electrocardiogram, basal metabolism, etc., are fed into the machine, it would issue a chart with previous characteristics superimposed on the latest ones for comparison. A diagnosis would also be undertaken by the computer and a cure recommended from the memory of treatments of similar conditions. Just how the medical profession would take to this computer is difficult to predict.

At the same session, Dr. A. C. Burton of the Medical School of the University of Toronto told how the circuit analysis techniques of electronic engineers are being successfully applied to analysis of man's circulatory system. He called for more engineers and physicists to enter medical research to help solve problems with engineering techniques such as circuit analysis.

A Problem for Management

To return to the question of the possible fading away of the Radio-Engineering Show, a number of problems are raised for technical management. To keep abreast of new developments, engineers and scientists should attend as many technical conventions as possible and meet other R & D people with varied approaches. But faced with an increasing shortage of technical personnel, many firms may decide to limit the number of shows each staff member can attend. Specialty conventions and shows may then win out over the big industry wide show. Perhaps that's what happened in many cases to limit attendance at the IRE Convention? The result could be less and less understanding between specialties and less shifting from one specialty to another, still a common practice. Do we need more or fewer engineers with a comprehension of the problems of their entire industry and profession?

Training Engineers



With the invasion of research and development into practically every sphere of business activity, more and more engineers are going to vacate the bench and enter management ranks. In an increasingly complex, technically-based economy, engineering provides an excellent background for management—provided, of course, that the executive candidate has what it takes to handle people effectively.

Training is one way of increasing the promotability of engineers. The management of people and of enterprises is fast becoming a science. As such, it can be learned. The matter of preparing scientific and engineering personnel for upgrading was one of the topics discussed at the recent Engineering Management Conference of the American Society of Mechanical Engineers in St. Louis.

Training on the Graveyard Shift

According to H. R. Kemmerer of Shell Oil Company, one of the conference speakers, "there are still too many research directors who believe that a new engineer has to

missile engineers

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Flight Test Engineering Section, which plans the missile test programs and establishes test data requirements in support of the programs. The data requirements are predicated on the test information required by the Engineering analytical and design groups to develop and demonstrate the final missile design, and are the basis from which the instrumentation requirements are formulated.

The analysis work performed consists of aerodynamic, missile systems, dynamics, flight control, propulsion and guidance evaluation. The Flight Test Engineering Section is also responsible for the field test program of the ground support equipment required for the missile.

Flight Test Instrumentation Section, which includes a Systems Engineering Group responsible for the system design concept; a Development Laboratory where electronic and electro-mechanical systems and components are developed; an Instrumentation Design Group for the detail design of test instrumentation components and systems; a Mechanic Laboratory where the instrumentation hardware is fabricated; and a Calibration and Test Group where the various instrumentation items and systems are calibrated and tested.

There are now a number of openings available for engineers in each of these groups at all experience levels.

If you qualify for any of these challenging opportunities, we invite you to contact Engineering Industrial Relations, Plant 2, Gate 3B, Broadway & Prairie, Northrop Aircraft, Inc., Hawthorne, California; or write Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., 1020 East Broadway, Hawthorne, Calif.

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learn the game the hard way, and this usually means operating pilot plants on the graveyard shift for months on end. Another old belief is that the engineer will understand his problems better if he learns how to do the chemical analysis or metallurgical examination on his own samples. This was true in the days when statistical significance of data was very little understood, but now that the analyst supplies a statement of the accuracy and precision of the test results along with the numbers, having the engineer do his own analysis as part of his training is a tragic waste of time.

"On the other hand, short training courses on management policies, lectures by outside authorities, seminars where laboratory staff experts in several fields discuss pertinent problems, and formal college short courses are all recognized today as effective and desirable aids in training and developing R & D engineers. In addition, participation of the engineer in professional society activities should be encouraged."

On-the-job Training

On-the-job training for engineers is too often an unplanned and inefficient procedure. To be effective it must be properly organized and directed. Said B. C. Boulton of McDonnell Aircraft Corp., another conference speaker, "There is great need for training supervisors in the proper techniques of training their men. To many young supervisors do not realize the importance of this phase of their work, and are so busy doing technical work themselves that they are reluctant to take sufficient time for the proper training of new men. Yet, their understanding of this problem and their cooperation are essential. They must be brought to realize the advantages to themselves and to their group, as well as to the man, of organized training which will more quickly bring new men up to a productive stage."

Promoting Engineer Development

"'Management Development Programs' have become a vital part of the modern engineering enterprise," said R P. Kroon of Westinghouse Electric Corp. "Today opportunities for education in management techniques, human relations, and business administration are readily available to anyone interested in management. Industrial concerns can promote the development of capable supervisors in several ways:

- Take a real interest in the individual engineer's growth
- Provide diversified experience
- Promote employee education
- Assist the colleges
- Relieve the engineer from jobs that can be done by others with less training.

The Humanities in Engineering Education

L. E. Lattin of Southwestern Bell Telephone Co. discussed the role of the humanities in engineering education. "I should like to take issue with some who turn re-emphasis upon the humanities into an advocacy of introducing humanistic studies into the engineering curriculum at the expense of strictly engineering subjects. We cannot set the clock back. We have specialization—call it narrowness if you like — for the simple reason that technological advance cannot be made without it and we shall have technological advance. It is necessary that each generation shall embrace all that has gone before and then make its own contribution. That requires categorizing and particular aim. It is not only inevitable in our economics but also it is essential to our defense."

Research Leaders to Tour Europe

Two American leaders in the field of industrial research are now in Europe to continue their work of stimulating more wide-spread interest in research programs there. The two, Dr. Edward R. Weidlein, recently retired president of Mellon Institute, Pittsburgh, and Dr. William W. Eaton, an industrial consultant with offices in New York City, will hold seminars in several European cities to acquaint industrialists and businessmen with the importance of applied research in the productivity cycle. The project is jointly sponsored by the International Cooperation Administration and the European Productivity Agency.

Last year the two men conducted a similar series of seminars on applied research in a number of European industrial centers. In Italy meetings were held in nine cities.

Although Europe's larger industrial firms have long used applied research to increase productivity, smaller firms are often unaware of the advantages of research or are financially unable to support industrial research programs. In their seminars Drs. Weidlein and Eaton hope to create a better understanding of the usefulness of research programs to small and medium-sized firms and to recommend ways to promote greater collaboration between established research institutes and these firms.

(Note: Dr. Eaton described his impressions of last year's trip in an article in RESEARCH & ENGINEERING entitled "Industrial Research in Europe—1955" which appeared in the October-November issue.)

AEC Declassifies Technical Reports

In a stepped-up effort to speed the flow of information to industry, an AEC special team has completed its review of 30,773 research and development reports and informal memoranda. The review work—aimed at declassifying or downgrading reports of potential use in the growing atomic energy industry—was done at the Commission's Oak Ridge Operations Office by a team of 35 scientists and engineers from major Commission installations in the U.S.

Of the more than 30,000 classified reports reviewed, 10,916 were declassified, 8,574 were labeled "Confidential", and 11,283 remained in the "Secret" classification. Declassified reports go into the open scientific literature and are available without restriction to all who wish them. Classified reports are available in accordance with the Commission's regulation for access to Restricted Data.

Research Progress in Tin and Nickel

According to the 1955 report of the Tin Research Institute, substantial accomplishments have been made in tin research and development. Some of these achievements include development of the direct chloride method of tinning cast iron and a new test for assessing the corrosion resistance of tin plate. Study was continued on the flow-brightening of electrolytic tin plate; electrodeposition of tin and its alloys; the action of additives in tin and tin-alloy plating baths; the perfecting of certain techniques in producing aluminum-tin bearings; the adaption of the continuous casting process to produce thick slabs of bronze for rolling and extrusion; and the antifungal uses of organotin compounds. Other research included tin-indium and tin-thallium alloys.

In the nickel industry, International Nickel Company reported that current research includes development of nickel alloys having properties suitable for use in generating power at elevated temperatures and pressures beyond the limits of conventional materials. Inco is also researching nickel alloys for use in jet engines or gas turbines.

Value Analysis in Chemical Buying

From the amount of attention being given it, value analysis — the scientific evaluation of whatever costs money—has apparently "arrived" as a management science. Such large concerns as General Electric, Westinghouse, Ford and Monsanto Chemical seem to have jumped into it with both feet.

In a paper presented to the Chemical and Allied Products Buyers' Group of the National Association of Purchasing Agents, J. R. Sayers of Monsanto defined value analysis in chemical buying as the consideration of all aspects of a proposed purchase including (1) the material itself, (2) the positions of the material and its manufacturers in the market place and (3) the end use to which the material will be put, with the object of affecting a more economical purchase, thereby enhancing the buying company's profits.

When considering value analysis in the chemical buying field, said Sayers, the purchaser faces a combination of high capital requirements, highly integrated manufacture, well defined markets and market prices, stable pricing and strong selling. Value analysis in any field, he said, requires an extensive period of fact gathering including, among other things, market research, cost-price analysis, and an understanding of how the material is to be received, handled and used.

The first step in answering the questions raised by value analysis should be a study of the literature. In addition, Sayers suggests that chemists in the company's research department can be consulted. Engineering departments may also have evaluated the product or material in question.

Reading, talking and consulting should lead to information on the product and its chemical and physical nature, how the material is manufactured, the basic information for estimating its manufacturing cost and possibly, problems that others may have experienced in working with the material. In addition, research should determine the product's position in the market place, who makes it, why those particular companies make it, what kind of chemical family tree is necessary for economical manufacture of the product, what its price is, and the many factors which have affected its price in the past. With this knowledge of the material and its market, the only remaining information needed is data on the company's own use of the product.

New Ways to Relieve Bottlenecks in Analysis of Stainless Steels

For years, routine stainless steel analysis has been plagued by such problems as excessive exposures of the same sample, lengthy calibration time on different stainless steels, inconsistent results from samples of almost identical chemical composition, and severe drift of working curves.

What may be a way out of this dilemma has been suggested in a paper by L. O. Eikrem and J. S. Fipphen of the engineering department of Baird Associates, Inc., Cambridge, Mass.

At a meeting of the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, the scientists reported new levels of efficiency and accuracy in routine stainless steel analysis with spectrochemical instruments. The report indicated that values on the order of 1 percent of the amount present could be determined for major constituents. Although the data presented were concerned chiefly with chromium and nickel, it was reported that results for other elements are comparable in accuracy.

Apparent key to achieving such close accuracies is the attainment of stable working curves through careful source and line pair selection. Other important factors in developing this technique were use of a long (60 seconds) pre-exposure sparking period and a tungsten counter electrode.

In actual application of this method of analysis, substantial reduction in analytical time was recorded. During one phase of the study, some 25 different alloys, mostly stainless but some special alloys and tool steels, proved readable from the same basic curve.

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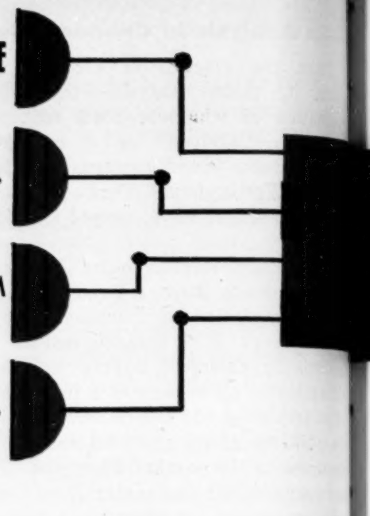
FOR MORE INFORMATION CIRCLE 15 ON PAGE 48

Information Theory has opened up new horizons of

The Quick Brown Fox Jumped Over the Lazy Dog

SHAEF TO UNICEF . . . URGENTLY NEED TWO CARLOADS OF SAFETY PINS. CHROM

Dear Babe. Meet me in Miami and bring Bikini. Love, Sugar



Electronics

The New Approach

Information Theory has opened up new horizons for electronics. Here, in answer to requests from many electronic engineers who were graduated before this recent advance became a part of the engineering curriculum, is a concise introduction to this new tool—a springboard to more intensive study of Information Theory as applied to electronics.

Arthur S. Zamanakos

Mr. Zamanakos, a graduate of Boston University, is a member of the Mathematics Staff of the Radar Division of the Naval Research Laboratory. He was formerly with the Bureau of Ships (Navy Department).

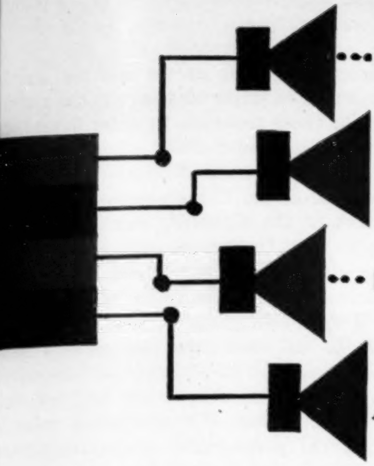
Information theory enables the electronic design engineer to tackle many of his problems in an entirely new manner. Equipped with the tools offered by information theory, he may find himself in the forefront of his field. Undoubtedly, however, many engineers who are now in technical management graduated from engineering colleges before information theory was a regular subject of study. In addition, the press of their duties may have prevented them from keeping up with the technical literature in the field. Based on professional practice in the application of information theory, this article should serve as an elementary introduction to the subject.

Determining the theoretical limitations of a transmission system is one of the major uses of information theory. One limitation imposed on the transmission system is due to thermal noise, which is inherent in the components that comprise the communications system. As one writer puts it, thermal noise may be described as the "electrical" Brownian movement. This movement takes place in a simple *R-C* circuit, and will be observed as voltage and current fluctuations. Further, it will be found that the mean-square voltage is

$$\overline{V^2} = KT/C$$

where K is the Boltzmann constant, T is degrees Kelvin, and C is the capacitance of the circuit. A visual example of this movement can be obtained by performing the following experiment suggested by F. W. Sears: Illuminate a cloud of smoke from the side and observe it from above using a low-power microscope. The particles in the cloud will move about in a manner similar to random motion of the molecules of a gas.

Another interesting example of Brownian motion of elec-



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The Quack Br.... ox Junked Upper the Lassy Do

... HAFE TO UNFIT . . . UGENTLE . . . EED TWACK ARLOODS OF STAFF TIE PINS . .

Deer Bube ... eet men My amian .. bigkinibig ... ovles .. ugh

trons and the resulting thermal noise is the following: Suppose one has a conductor of resistance R at temperature T. The random motion of the electrons will yield small voltage fluctuations across the ends of the conductor. The *average* value of this voltage fluctuation is zero. Nyquist showed that the spectrum of these voltage fluctuations is *constant* up to very high frequencies so that for all practical purposes one can consider it a *white spectrum.* Noise of this type is often a nuisance, but instances exist where thermal noise may be the only source of information to assist you in your problem. This situation is especially true in the studies of shot effect and electron emission from a cathode surface.

Noise Compared to Entropy

The concepts of noise can be compared to those of thermodynamic entropy, obtaining a glimpse of information theory in the embryo stage. If noise is defined as random activity, then information can be considered as order wrenched from disorder, as improbable structure in contrast to the greater probability of randomness. With this concept the laws of classical thermodynamics express the universal trend toward more probable states. We will be able to see that information can be formulated as negative thermodynamic entropy, and a precise measure of certain classes of information can be found by referring to degrees of improbability of a state.

It may be wise at this early stage to mention the various interpretations of thermodynamic entropy and entropy used in discussions of information. As Brillouin points out, information is negative thermodynamic entropy, as may be shown in the equation

$$S_1 = S_0 - I$$

where S_1 is the present thermodynamic entropy of a system, S_0 is the initial thermodynamic entropy of the system, and I is the information given off by the system in its transition from S_0 to S_1. Using one interpretation of the Second Law of Thermodynamics, i.e., the thermodynamic entropy of an irreversible system does not decrease or $S_1 \geqq S_0$ we are able to analyze this equation and determine the character of I. (It should be noted that this interpretation is not acceptable to all workers in the field.) Therefore, from the manner in which I appears in the above equation it may be inferred that I is a negative thermodynamic entropy. In this derivation the concept of thermodynamic probability enters into the picture and will be subsequently explained. Boltzmann explained the concept of thermodynamic entropy and information very nicely when he stated that thermodynamic entropy is a measure of missing information so that when a system goes from one state to another, the difference in thermodynamic entropies is a measure of the information we have gained about this system.

In many papers in this field the terms "information" and "entropy" (not thermodynamic entropy) are used interchangeably. This situation may be due to Shannon's use of the terms. He defines information, H, in terms of statistical probabilities. The form of H is very similar to that for I, and so he calls H entropy. The important distinction between terms is that I is given in terms of thermodynamic entropy and H in terms of statistical probability. This distinction of thermodynamic entropy and entropy will be further clarified as we proceed.

Picture a particle in space that is free to move about. It is easy to see that the position of the particle may be described by giving its three position coordinates (x, y, z) and that its motion may be described in terms of the x, y and z velocity components. If, then, we use all six factors to describe the characteristics of this particle, we have a six-dimensional hyperspace or a *phase space.* That is, a phase space is described by coordinates of position and momentum (velocity). The particle is said to have six degrees of freedom, that is, it will be completely specified by giving these six coordinates. This idea may be generalized in the following manner: A given body of gas, or liquid, or a solid will be called a system, or more specifically, a thermodynamic system. If it has n position coordinates, then its complete mechanical state can be specified in terms of n generalized (position) coordinates and n generalized moments — a total of $2n$ numbers. This system is said to have a phase space of $2n$ dimensions. It should be realized that n is equal to three times the number of particles or elements that comprise the system.

Let us prescribe that our phase space contains N phase points and is divided into unit elements of volume. The $2n$ coordinates that locate a phase point describe the state of the entire system for a particular time. It is then possible to find N_1, N_2, N_3, . . . or . . . N_k phase points in these elementary units. ($N = N_1 + N_2 + \ldots + N_k$). We may define *thermodynamic* probability, W, as being equal to

$$W = \frac{N!}{N_1! \,.\, N_2! \ldots N_k!}.$$

This expression is merely the combination formula for the number of ways in which the $N_1, N_2, \ldots, N_k$ points may be grouped. It should be noted that this is not probability in the usual sense in that probability usually ranges in value from zero to unity while thermodynamic probability as given here is equal to or greater than unity. Using this expression for thermodynamic probability, the thermodynamic entropy S of a given system is defined by the

$$S = K \ln W$$

where K is the Boltzmann constant.

Shuffled Cards Have High Entropy

A mental picture of the thermodynamic entropy concept can be drawn by using the following two examples. A new pack of cards with all suits arranged in sequence is to be assumed as having a high degree of order and hence very little disorder and a low entropy. As the pack is shuffled, the order decreases, the disorder increases, and therefore the entropy increases. In this instance, since there are a finite number of arrangements of the cards, it is perfectly conceivable that the original order may reappear. We must therefore assume that the number of shuffles (say 15) is much smaller than the possible number of card arrangements (which is 52!). Consequently, the possibility of the original order reappearing can be assumed to be zero and that the entropy increases during this limited number of shuffles.

For the second example, consider a gas in space. The greatest degree of order of the phase points of a gas in phase space results if all are in a single unit of volume element of the phase space; i.e., if all are in a very small volume in ordinary (three-dimensional) space and all are traveling with the same velocity. The thermodynamic probability of such a state has its minimum value of unity and the thermodynamic entropy is zero. The more the particles spread out in velocity space, as they do with increasing temperature, the greater the disorder and the larger the thermodynamic entropy.

A group of definitions in a rather compact form is available that effectively describes some thinking in the field of information theory, which is concerned with the making of representations. These representations are to be considered as symbolism, abstract or concrete, in a very general sense. Information theory involves at least three classes of activity:

(1) Making a representation of some physical aspect of experience—the problem treated in scientific information-theory.

(2) Making a representation of some non-physical (mental or ideational) aspect of experience—the problem of the Arts.

(3) Making a representation in one space B, of a representation already present in another space A—the problem of communication theory.

We mean by a space any physical or abstract mathematical coordinate-framework or manifold, of any number of dimensions, in which the elements of a representation can be ordered.

The relationships that exist between information theory, mathematics and physics are shown in Fig. 1. Information theory is pictured as being the focal point, a valid assumption since mathematics and physics may be thought of as tools which enable one to work with the concept of "representations" which is the heart of information theory. The representation is any structure that corresponds to another structure; there may be a one-to-one correspondence. A very elementary example would be the correspondence of the English word for "black" to the French word "noir". This relation of course is part of a many-to-one or one-to-many correspondence since there are many languages. Another example may be the correspondence of a point in phase space to the state of a particular system of thermodynamics.

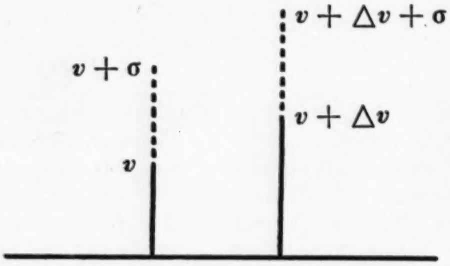


Fig. 1. Noise, shown by broken lines, makes it difficult to determine signal changes.

Hartley Proposed "Amount of Information"

R. V. L. Hartley was the first to deal with the concept of "amount of information". He also proposed the means by which we can calculate the quantity H, which he calls the "measure of information". Notice the similarity between his equation and the standard equation for thermodynamic entropy given above.

Let us follow his development and see how he arrived at the formula

$$H = n \log S$$

for the measure of total information. To begin with, suppose we are in the process of transmitting a message. At the moment we are not concerned with the type of transmission, but as we will see later it plays a very important part in the application of these theories. In order to send our message we must make a certain number of selections from S symbols which are available to us. These symbols may be the letters of the alphabet, numbers, dots and dashes, etc. Our message is assumed to be n symbols long. Therefore we must make n successive selections from the same group of S symbols. These S symbols are available to us each time we make a selection. Actually this amounts to choosing one message out of S^n possible messages each n symbols long. We obtain the value S^n using the permutation theory of algebra. The first selection requires us to pick one symbol out of S symbols. The second selection again requires us to make a selection from S symbols, but now each of the S symbols from the second selection may be matched with each of the symbols from the first selection. We therefore have S^2 [$=(s)$ (s)] sequences of two symbols.

The third selection provides us with the S symbols from which to choose. Each of these S symbols may be matched with each of the previous S^2 possible sequences. Now we have S^3 [$=(s)(s)(s)$] sequences of three symbols. This process is performed N times, thus giving the result S^n as the total number of sequences of N symbols long from which we must pick one. Let us illustrate this process using the letters A, B, C and D, that is $S = 4$. Let us assume that our message is to be three letters long, that is, $N = 3$. The selection process at each of the three selection stages is illustrated in Fig. 2.

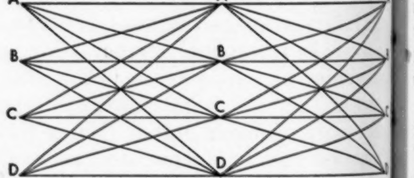


Fig. 2. There are a number of paths between the first and third selections via the second one.

The diagram shows the various paths you may take in going from the first selection to the third selection via a second selection. Each path represents a sequence of three symbols. We have four possible choices at the first selection and four choices at the second selection for a total of 16 paths that we may travel in going from selection one to selection two or 16 two-symbol sequences. Now the third selection also offers four choices, thereby providing us with four paths for each of the 16 paths already obtained for a total of 64 paths or 64 three-symbol sequences. Equationwise, this process takes the form

$$[(4)\ (4)]\ (4) = [4^2]\ 4 = 4^3 = 64$$

The process may also be shown by multiplying out $(A + B + C + D)^3$ and maintaining the order of multiplication since it is not a commutative process; i.e.,

$$AB \neq BA, ABC \neq CAB \neq BAC$$

This may not be multiplication as usually understood, but rather it may be a sequence of operations.

Considering the manner in which a gambler decides to bet in a dice game is another way of illustrating this situation. He knows that each die may show one of the numbers from 1 to 6 and since two dice are usually used, the numbers 2 to 12 may appear. He further knows that the numbers 2 and 12 can be formed in only one way, i.e., 1 plus 1 and 6 plus 6; 3 and 11 may appear in two ways each; 4 and 10 in three ways each; 5 and 9 in four ways each; 6 and 8 in five ways each; and 7 in six ways. This is a total of 36 numbers, not all different. In this example $s = 36$ and $n = 1$ (roll of a pair of dice). With this *information* the gambler may then construct his betting odds based on the probability that a certain number will or will not appear.

We may then define the measure total of information H as equal to log S^n. The number S depends upon the type of transmission being employed. In all instances it must be equal to or greater than 2, or else we would not be sending any information. This definition leads us directly to the implication that the greater the range or magnitude of selection we have, the greater is the measure of information. In other words, the greater the unexpectedness of the selection the greater the measure of information. Since the logarithm is a monotonically increasing function, we use it to calculate information because it satisfies the intuitive requirement that the greater the selection available (or the unexpectedness) the greater should be the measure of information. The logarithm also makes some of the limiting processes easier to handle.

Hartley's application of this concept to facsimile transmission is worth repeating: The total number of selections n will be equal to the number of squares into which the picture is divided (just as the phase space was divided into unit elements of volume). These squares may differ from each other in their average intensity (just as the unit volume in the phase space may or may not have contained any particles). The number of different intensities that may be correctly distinguished from each other in each square of the reproduced picture represents the number of symbols S available at each selection. Hence the total information is given by the number of squares times the logarithm of the number of distinguishable intensities.

Ideas and Expressions in Information Theory

Let us now begin to examine some of the ideas and expressions employed in information theory. When considering the information content in a message we find two aspects with which we must contend: the *a priori* and the *a posteriori* attributes of the message. These attributes are described in the following manner: The a priori portion of the message, the structural information, is called the "logon". The logon enables one to make a differentiation or distinction. A group of logons will constitute a message or information. This definition implies that the operating characteristics of the system with which we are working will supply in advance the a priori knowledge. The a posteriori contribution is called the metrical information and its unit is the "metron". The output of the system will be a series of amplitudes measured to some degree of accuracy. These amplitudes and the associated accuracy is an example of metrical information.

We may illustrate these attributes by the following examples: First, a word or sentence can be represented by a sequence of air vibrations. The structural information content of such a message is given by the number and the time distribution of the readings of air pressure necessary to be taken at a fixed space point to characterize the vibrations. The metrical information content of the message is determined by the numerical value of each of these pressure readings, and the accuracy with which each can be measured. Second, a television picture can be represented by a space-time distribution of light intensities. The structural information content of such a message is given by a knowledge of the number, position and timing of the light intensity pulses, over some finite interval of time. The metrical information content of the message is then determined by the numerical value, together with the reproducibility of each of these intensity readings.

The ability to recognize a message is expressed by the term "measure of selective information". In a binary system of selection the unit is the "bit". Here the bit defines the uncertainty attached to the choice of one message from a pair of equally probable messages. It has been pointed out that the simple "flip-flop" relay can store one bit of information. We can see from the above that the unit of measure of selective information (and therefore the base of the logarithm) is dependent upon the type of transmitting system used.

Knowledge May Increase in Three Ways According to MacKay

Information may assume different forms and thus increase knowledge by varying degrees. Knowledge according to D. M. MacKay may increase in three ways, due to: (1) the "unexpectedness" of the addition of knowledge; (2) the "complexity" of a measurement; and (3) the "confidence" of a reading (of a dial, gauge, etc.). With these concepts of information you can formulate general principles applicable to the design of optical instruments (revolving power), galvanometers (response-time), and communication channels (bandwidth). The engineer will find a wealth of material in various technical journals and periodicals illustrating the application of these principles.

Hartley's formula for the "amount of information" was developed on the assumption (or hypothesis) that all selections were equally probable. This assumption is indeed a special condition that is not likely to be found too often. For example, if English text is being transmitted we know from experience that the probability of sending the letters *e* or *a* is much greater than for *y* or *z*. Therefore, when the selections are not equally probable, we must introduce a new formula. This new formulation for H as given by Shannon is

$$H = -\sum_i p_i \log_2 p_i$$

where p_i is the probability of a certain choice being made. (The negative sign produces a positive value of H since $p_i \leqq 1$.) The logarithm to the base 0 signifies that our technique of transmission involves a binary system. The unit of information is the "bit" for this technique. This formulation for H represents the "average information per symbol". The "total information" which would be analogous to Hartley's H would be.

$$-n \sum_i p_i \log_2 p_i$$

where n is the message length.

In an analogous manner we may define the entropy of a continuous distribution with the density distribution function $p(x)$ by

$$H = -\int_{-\infty}^{\infty} p(x) \log_2 p(x)\, dx.$$

For an n-dimensional space the form is

$$H = -\int_{-\infty}^{\infty} \cdots \int_{-\infty}^{\infty} p(x_{17} x_{29} \ldots, x_n) \log_2 p(x_{11}, \ldots, x_n)\, dx_1 \ldots dx_n.$$

As Shannon points out, an important difference exists between the discrete and continuous types of entropies. The discrete case gives an absolute measure, while the continuous case gives a relative measure of entropy. This relative measure is dependent on the coordinate system being employed. That is, a change of coordinate systems will produce a change in the (relative) measure of entropy. Also, since a translation of axes is possible, we can end up with a negative measure of entropy. This is not possible for the discrete case.

Shannon also points out that the importance of this measure of information, H, is that it makes it possible to determine if any saving in transmission time is possible. This saving is obtained from the proper choice of encoding—the process that takes place in the transmitter. The encod-

ing technique applicable in each instance is dependent upon the statistics of the information source. The economics of the technique must also be considered; that is, a complex and expensive encoding apparatus may perform the necessary function, but its cost may be prohibitive.

We previously considered the problem of describing a particle or body in a multidimensional space. The number of dimensions of this space was dependent upon the degrees of freedom that the particle was said to possess. We will now apply this concept to a signal.

Shannon's Sampling Theorem

We have a communication channel that transmits a signal $f(t)$ which is a function of time and is band-limited (W cycles/second wide). Shannon's Sampling Theorem is: If a function $f(t)$ contains no frequencies higher than W cycles per second, it is completely determined by giving its ordinates at a series of points spaced $1/(2W)$ seconds apart. Therefore, our signal function may be described by giving its amplitude value at these selected points, $1/(2W)$ seconds apart. Thus, in this instance we may say that this signal function has $2W$ degrees of freedom per second.

The next important step is to see how Shannon developed the formula for the *capacity* of a communication channel. For the time being let us define this capacity as the rate at which a communication channel transmits information expressed in bits per second.

We begin with the following conditions: (1) The average power delivered by a transmitter is not greater than P; (2) The noise power N is that power which would be delivered to a standard unit of resistance and $\sigma (=N^{\frac{1}{2}})$ is the standard deviation of this noise; (3) W is the band-width of the channel. Instead of dealing with n dimensions and generalized volumes as Shannon does, we will attempt to work in a one-dimensional space, that is, with voltage amplitudes.

In Fig. 3 let v be some pure instantaneous signal voltage. But due to noise we may have instead $v+\sigma$ as the amplitude. Now let there be another pure signal voltage $v+\Delta v$. But, again, due to the noise we may have $v+\Delta v+\sigma$. The questions that confront us are: (1) When can we be sure to distinguish between v and $v+\Delta v$? and (2) How many different values or levels of voltage can we distinguish in the dynamic range $V=(P+N)^{\frac{1}{2}}$? Superimpose one of the amplitudes given in the sketch upon the other. If Δv is less than σ, the dashed segments will overlap. This condition results in a certain amount of confusion or doubt; that is, we would not know if the incoming signal should be v or $v+\Delta v$. Next, if Δv is greater than σ, we definitely can distinguish between v and $v+\Delta v$ but we are being wasteful, and therefore we must reduce this intervening gap which represents waste. If we set Δv equal to $\sigma+\varepsilon$ (and let $\varepsilon \rightarrow 0$), we will definitely have no overlap and for all intents no gap. Thus there will be no confusion and no waste. Following this argument we may say that we will be able to distinguish almost v/σ different voltage amplitudes or in terms of our original power relations, $[(P+N)/N]^{\frac{1}{2}}$.

The *received* signal power is equal to $P+N$. As we have shown we can distinguish approximately

$$\sqrt{(P+N)/N}$$

different (voltage) amplitudes at each of the points previously mentioned in the second previous paragraph. We can think of these points as being samples taken every $1/(2W)$ seconds. If we had almost *no noise* we could distinguish many amplitudes. Conversely, if we had a large magnitude of noise we can see that we would not be able to recognize the received signal amplitudes; in other words, our signal would be completely buried or masked by noise. Taking the logarithm (to the base 2) of this ratio we obtain the amount of information in bits contained by one point; that is,

$$\log_2 \sqrt{(P+N)/N} = 1/2 \log_2 (P+N)/N \text{ bits.}$$

Since there are $2W$ independent samples (or points) per second, the capacity of the channel is

$$C = W \log_2 [1 + (P/N)] \text{ bits/sec.}$$

When P/N is small we may obtain the following simplification:

$$\log_2 [1 + (P/N)] \cong (P/N) \log_2 e$$

$$\cong 1.443\, P/N$$

Thus

$$C \cong 1.443\, WP/N$$

As Shannon points out, the equation for C implies that there may be ways of reducing our bandwidth requirements. One way would be a direct swap between the signal-to-noise ratio and bandwidth. The next, but not so evident, way would be to utilize the statistical correlation that may exist in the message. Here the technique depends on the particular properties of the information source, and can be regarded as "matching the source to the channel". The final method considers the properties of the destination. For example, in speech transmission the ear is relatively insensitive to phase distortion. Consequently, phase information need not be transmitted very accurately (as compared to amplitude information). This provision results in a bandwidth saving, since we now need less than the usual $2W$ samples per second to specify the time function in the given time T.

Further examination shows that while bandwidth can be saved (in the ideal system which makes full use of the signal space) at the expense of the signal-to-noise ratio the saving is very expensive because of the fact that the logarithm changes very slowly with changes in the power P; i.e., you must increase the transmitter power two times to obtain a 10% reduction of the bandwidth without harm to the signal.

"Equivocation" Necessary to Correct Errors

"Equivocation" or conditional entropy is another factor. Equivocation is important because it represents the amount of additional information that must be transmitted to correct errors in the reception. These errors were produced by the presence of noise in the channel connecting the transmitter and the receiver. Equivocation can also show how guessing destroys information. Further, a thorough comprehension of equivocation will enable an engineer to devise a transmitter that will encode his information in such a manner so as to (1) make full use of the system's channel capacity, and (2) include additional information to correct errors in the reception due to noise. In other words, what is the best that you can expect under existing conditions? Equivocation will provide you with an answer.

The extent to which information theory will be applied appears to be limited only by one's imagination. D. Gabor, for example, would have us consider the phase change in an electro-magnetic signal due to the interaction of the signal with the electrons of an electron tube. By treating the signal output of the electron tube in terms of quantum theory and by the application of information theory you may obtain the information content of the original signal from the corrupted signal. It attempts to nullify the phase change by making photon measurements rather than the simultaneous phase and amplitude measurements which are otherwise necessary. An *ideal* photon counter is insensitive to phase changes. Therefore, it can provide you with measurements which, in turn, may be interpreted into "information". (A similar situation arose in the speech problem.) A comparison with previous examples will show that the frequency and number of photon measurements constitute the structural information and the magnitudes of the photon measurements constitute the metrical information.

Currently, information theory is being applied in the search for a solution to what may be called "the radar problem". The aim of information theory in this case is to provide or determine the radar system parameters so that the system will yield a specified degree of operational efficiency. This system performance is to be attained in the presence of a high noise level which ordinarily prevents early target tracking.

Editor's Note: ***Those interested in further reading in Information Theory may obtain a bibliography of books and periodical literature on the subject by writing to*** **RESEARCH & ENGINEERING,** ***Editorial Offices, 77 South St., Stamford, Conn.***

CERIUM OXIDE

—a rare earth that sparked a revolution in a long established art in the glass industry

a report by LINDSAY

Some twenty years ago in Switzerland, two technicians discovered the amazing glass polishing properties of Cerium Oxide. Soon it was being used extensively for polishing of precision lenses in Europe.

Then came World War II. Scientists in the optical industries in this country heard about Cerium Oxide . . . how it could polish faster and cleaner than any other known material. They thought that maybe this was the answer to the problem of accelerated production of precision optical pieces for our war machine. In a cloak and dagger operation, samples of Cerium Oxide were smuggled out of Switzerland. Tests confirmed the rumors . . . Cerium Oxide was IT!

This was early in the 40's when Hitler held most of Europe and the Japanese were driving toward Australia. The urgency of our growing war effort was putting fantastic demands on the optical industry. Lenses for bombsights, range finders, periscopes and other military instruments were needed desperately. Production had to be increased manyfold with no sacrifice of split-hair accuracy.

Lindsay, the nation's largest processor of monazite (the chief source of rare earths), undertook in 1942 the challenging task of producing Cerium Oxide. Day after day, Lindsay technicians worked with patience and speed to solve the inevitable production problems and in a remarkably short time, Cerium Oxide was being refined with the properties that met the demanding standards of the optical and glass industries. At about the same time, Barnesite, a rare earth oxide for ultra-high precision work, was developed and a few years later Lindsay took over exclusive production.

By war's end, Cerium Oxide had virtually revolutionized glass polishing practices in this country. Today, it is widely used in the production of distortion-free TV tubes, fine quality mirrors and precision optical lenses.

Opticians like Lindsay's Cerium Oxide (sold under the trade name CEROX) because it enables them to polish lenses to prescription specifications faster and to give you glasses exactly as the doctor ordered.

Leading automobile manufacturers use Lindsay's Cerium Oxide to polish out windshield scratches just before shipment. One of the largest producers furnishes its dealers with kits containing Cerium Oxide to remove nicks and scratches picked up in transit.

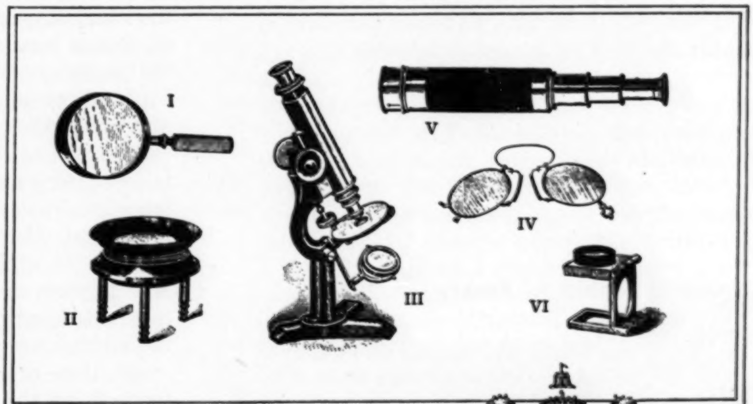
Why is Cerium Oxide such wonderful stuff when it comes to polishing? Frankly, nobody knows. Lindsay's technical people have tested and retested it, put it through countless laboratory analyses and peered at it for hours through high-powered microscopes. Just as scientists know how to *use* electricity, but don't know what it *is*, so too, they know that Cerium Oxide is a remarkably efficient polishing agent but *why* is still a mystery.

Like all the other rare earths, Cerium Oxide is a versatile material. Research disclosed its unique potentials (along with didymium, neodymium, and other rare earths) for use in coloring and decolorizing glass and it is extensively used for that purpose. Another interesting use is as a catalyst with some chemical materials.

Twenty-five years ago, most chemists had little knowledge or curiosity about the rare earths. Then the dramatic emergence of Cerium Oxide as an important factor in the optical industry excited interest in the full range of the 15 rare earth elements—atomic numbers 57 through 71.

There are technical people who think that some of the rare earths have greater possibilities of revolutionizing processes in their industries than Cerium Oxide has had for polishing practices. We are encouraged to think so, too. We are shipping rare earths regularly for use in the production of such diverse materials as steel, aluminum, glass, ceramics, textiles, ammunition and for a variety of applications in the electronic and atomic industries.

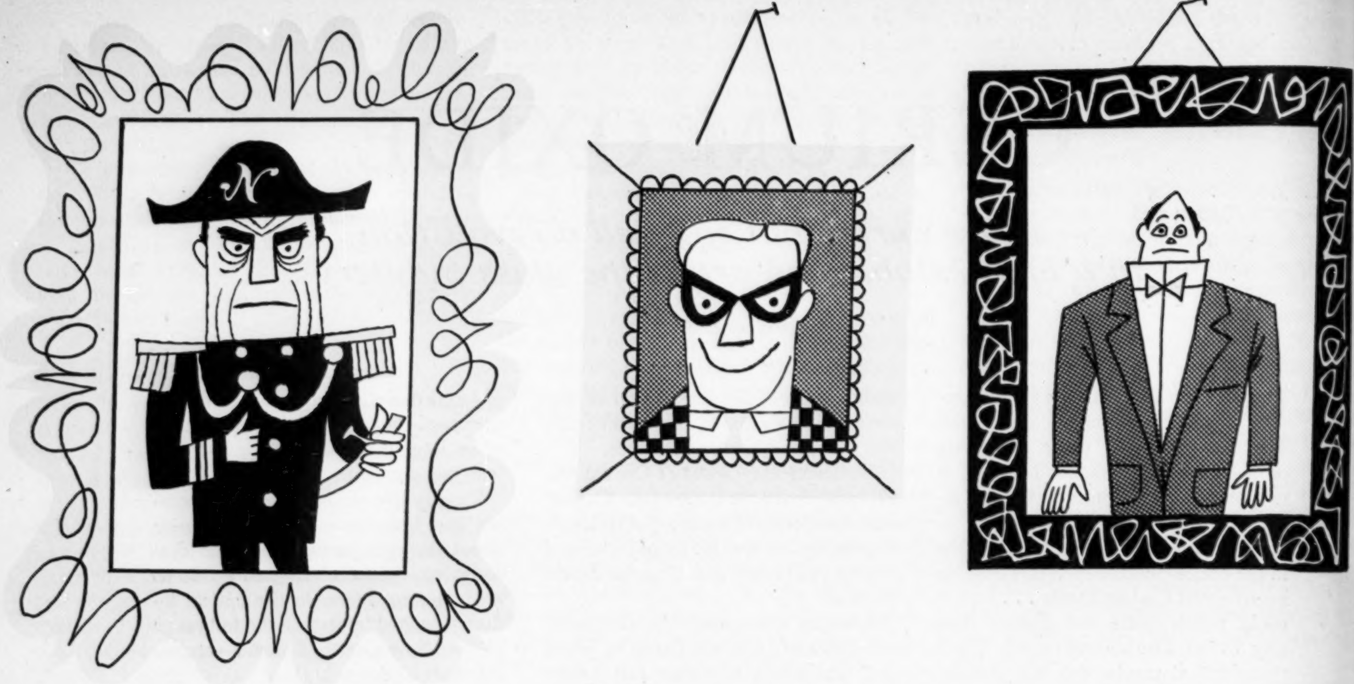
We can give you comprehensive data about the many rare earth and thorium salts available. Your technical staff may find it rewarding and profitable to take a long, thoughtful look at these unique materials, to examine their characteristics and, particularly, their potential applications to your own processes.



PLEASE ADDRESS INQUIRIES TO: LINDSAY CHEMICAL COMPANY

274 ANN STREET, WEST CHICAGO, ILLINOIS

FOR MORE INFORMATION CIRCLE 16 ON PAGE 48



HOW DO YOU RATE AS AN R & D MANAGER?

If it is carried out on a continual basis, the job of managerial self-analysis can be highly rewarding. Unfortunately, too many R & D managers never take time out to assess objectively their strong points and weaknesses. But even when they do, self-appraisal is only a point of departure. From then on, it's a matter of finding the best ways to remedy the indicated weak spots.

David A. Emery

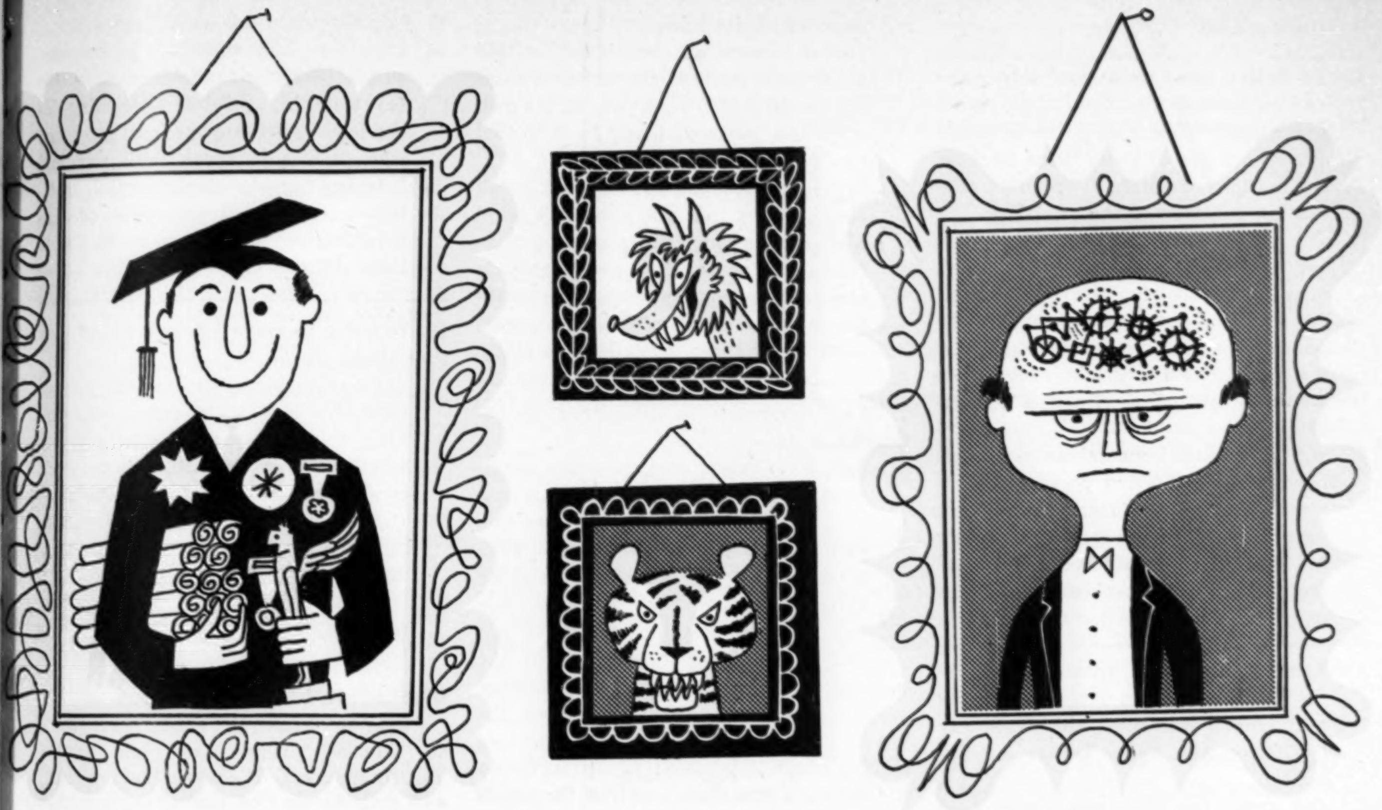
Dr. Emery, who received his Ph.D. in Social Psychology from M.I.T. in 1948, is presently a consultant to General Electric's Advanced Management Course at Ossining, N. Y. Past affiliations include the American Management Association and the Research Institute of America.

Research and development, as a separate, distinct and organized corporate activity, has come into its own over the relatively brief span of the past 10 to 15 years, or since the beginning of World War II. And with the new status and respect accorded R & D by company top management and the public has come a whole series of challenges for today's R & D manager.

During 1956 and for every foreseeable year to come, these challenges will be equalled by few positions in our modern technological system. Consider, for example, the challenge of automation; the challenge of frontier research; the challenge of R & D management itself. Last but by no means least is the big challenge of finding and training the necessary staff so that the research machine may be kept rolling on all 16 cylinders, with maximum efficiency and productivity.

Since one of the R & D manager's primary responsibilities is to acquire and develop his staff, he must have sufficient technical know-how to appreciate the problems of his subordinates. Moreover, in dealing with personnel, he must possess the ability to plan the scope and objectives of an R & D program for his group; to divide this program into integrated, workable units; and to grasp the complex relationships between these units.

All this, of course, requires more than technical competence on the part of the technical manager. It means more than being a top-notch man in one or several fields. The R & D manager must, in addition, possess managerial ability and skill in working with and through people: He must deal successfully with top management; he must retain the cooperation of his associates in other departments;



and he must provide enlightened leadership for his own.

It all adds up to this: If you're an R & D manager today, you don't just face problems similar to those of regular managers—YOU ARE A FULL-TIME MANAGER. And you are likely to have more managerial problems than other types of managers because you are dealing chiefly with well educated, creatively-inclined people.

Relationship Between Technical Competence and Managerial Ability

The question is: How good an R & D manager are you? As you develop your answer based on the self-analysis questions in this article, bear in mind that no systematic evidence exists to indicate a correlation between technical competence and managerial ability. If anything, there is some reason to believe that they are inversely related. Some psychologists suggest that the type of person who is willing to bury himself in concentrated study and research is innately less likely to have easy relationships with people. Others blame the years of study rather than any inborn tendencies, pointing out that technical people by-and-large never have had time to develop their social skills.

If there is any validity in either of these theories, the result is a double challenge for the R & D manager: He approaches the job of managing with a personal handicap, and he must manage men who are also more likely to feel at home when dealing with a mathematical, rather than a human, equation.

You say you like people? Find them easy to deal with and responsive to your approach? Fine—but it's still worth pausing to reflect: A manager can be popular with his superiors, his associates and his subordinates—*and still be a weak manager.*

Whatever your personal ability as a manager (as judged by yourself and others), you might like to gauge it in a more formal fashion. The self-analysis questions in the checklist below cover such critical areas of management as policy formulation, planning, selection of personnel, performance appraisal, communications, and others. After you've checked the answers that fit you best, turn to page 26 for a discussion of the questions and how a first-rate manager might answer them.

Your Self-Analysis

1. In planning research programs, it's your feeling that—

☐ (a) any attempt to look more than six months ahead is a waste of time and can lead to costly mistakes.

☐ (b) competent managers have their plans for the year ahead pretty well pin-pointed, but limit their projections to a 12-month period since anything beyond that puts you in the "crystal-ball" department.

☐ (c) the further one looks ahead and the longer the range is covered by specific plans, the better it is for the R & D department and the business as a whole.

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2. Company and departmental policies should be—

☐ (a) an unwritten, but thoroughly familiar code that outlines company-wide and departmental "ground-rules."

☐ (b) guides to behavior at the company and departmental level that are written down in general terms only and available to employees upon request.

☐ (c) detailed treatments of what is, and what is not permissable in your particular organization that are spelled out in writing and distributed to every individual in

the company.

3. To select new men, you rely on—

☐ (a) an extensive battery of psychological tests. You feel that personal interviews are of little value because impressions are often founded on misleading behavior of the candidate.

☐ (b) independent reports of his past performance by those to whom he was directly responsible. You feel that all too frequently, people can turn on the charm for their hiring interview and can even give the "right answer" to written tests of ability and personality.

☐ (c) your own impressions as developed in an extensive personal interview covering the man's past work experience, his reason for leaving his last job, his long-range work objectives and why he thinks your company is a good place for him to work.

4. Your approach to training is to—

☐ (a) allow maximum freedom for the individual's initiative and ingenuity by letting him figure things out for himself.

☐ (b) apply the "baptism under fire" approach of putting a new man right to work on important work and giving him a helping hand when he needs it.

☐ (c) hold off on assigning the newcomer to any real work until he has completed a series of training assignments that are similar to his future work but do not involve any significant company expenditures.

5. When it comes to appraising a man's contribution, you—

☐ (a) hold regular appraisal interviews at least once a year in which you and your subordinate discuss his performance to the point of mutual understanding as to where his major strengths and weaknesses lie and what both of you will do to help him.

☐ (b) leave this matter up to the employee as long as his performance is satisfactory.

☐ (c) feel that performance is a matter for action rather than words. Your people will know soon enough when they're slipping, and their pay and promotions will tell the story.

6. Concerning employee information about company and department objectives, plans and decisions, it's your judgment that—

☐ (a) the less an individual knows about matters beyond his control, the less he's likely to worry and the more he'll be able to concentrate on his own responsibilities.

☐ (b) the more an individual is told about such matters, the better his understanding of the purpose of his own work and the more likely he is to feel like part of the team.

☐ (c) it's all right to tell employees about things that you shouldn't mind having your competitors know, but information concerning new products and policies, coming changes in methods, and so on should be top secret until the changes actually take place.

7. Your approach to delegation of authority is to—

☐ (a) give every employee the maximum amount of authority be can possibly carry, on the grounds that this will stimulate personal growth even if it causes an occasional mistake along the way.

☐ (b) grant a certain amount of authority but keep it well within the limits of what you are absolutely sure the man can handle. This gives the individual a feeling of security.

☐ (c) limit delegation of authority to the bare minimum required for effective completion of the work, since it's much better to have a man coming in occasionally for help and guidance than fouling up costly operations.

8. Communications among your subordinates should be—

☐ (a) limited to just what is absolutely necessary in order to get the work done, since anything beyond this actually amounts to lost time. If permitted to run unchecked, this over-communication can add up to a serious cost leak.

☐ (b) allowed to run its own course. Since outright restraint may be resented, you feel it's better to keep hands off and just set a good example by holding your own communications to a minimum.

☐ (c) encouraged. You feel that free-and-easy communication among your group is essential to building team spirit. Also, it is a good means of spreading the know-how possessed by your more experienced men.

9. You keep tabs on developments among your people by—

☐ (a) watching performance and expenses. These two critical measures can tell any intelligent manager all he needs to know about his department.

☐ (b) watching results, and holding occasional confidential chats with certain key men whose attitudes reflect a better understanding of management's problems than others.

☐ (c) watching results, welcoming interviews with anyone and everyone who desires to speak with you, and holding regular departmental meetings in which all are encouraged to bring up anything they would like to have discussed.

10. In order to make efficient use of your own time, you—

☐ (a) budget your time for the various activities you must carry out, running an occasional check to verify whether your typical day, or week, comes anywhere near to budget.

☐ (b) instruct your secretary to screen callers and at certain times to allow only critical calls to come through.

☐ (c) take things pretty much as they come, allowing the demands of the business to determine your schedule.

Discussion of the Questions

Planning Research (Item 1). (c) is our choice. Long-range planning can lead to mistakes, of course, but it's pretty well established that one of the key characteristics of the successful manager is his consistent looking ahead. This is particularly true of the successful R & D manager. In top management circles one of the ways of judging how "big" a man is, is by how far ahead he plans. In General Electric, for example, managers are expected to plan in two phases: "short-range" plans for the next 18 month period, and "long-range" plans for the next five years. Some companies even ask their executives to plan ahead on a 10-, 15- or 20-year basis.

Policies (Item 2.) This is a "catch" question in the sense that any one of the three alternatives can be the best one for you—depending upon the type of organization to which you belong. For example, in a small company with long-service employees and a very low turnover, policies may be so well known that the appearance of a formal, written list could be a disturbing factor (if interpreted as meaning that top management was "cracking-down", or that "we're no longer able to reach understanding on a personal, man-to-man basis".

In larger organizations, it has generally been found helpful to put policies in writing. But just how specifically the policies should be spelled out, and how they should be distributed is again a matter of individual cases. Where the "climate" of human relations is favorable, it is advisable to formulate general policies which clarify management's attitude, but leave the details up to the imagination and sense of responsibility of the individual. On the other hand, where

management is burdened with a bunch of "sea lawyers" in its ranks, it may be necessary to spell out specifics—even to the penalties involved.

Selecting New Men (Item 3). This is also a "catch" question, in the sense that no one of the alternatives listed is as good as using any two, or better still, all three. The selection of a future technical employee deserves all the time and effort you can give it, since there are so many critical factors to be checked. Among the most important are—

...his personal and business ethics (beware if the gap between the two is significant);

...his technical competence;

...his general attitude towards his fellow men;

...his sensitivity and flexibility (the two most important traits where technical and personal growth are desired).

The conclusion, then, is to get as broad a sample of the candidate's personality and behavior as one can. Psychological tests can help—particularly when it comes to uncovering serious personality disorders and as a means of confirming impressions gained through personal interview. Checks on past performance are a must, and be sure to get reports from more than one source to eliminate possible bias. But even where the past reports are doubtful, you owe it to the candidate and to yourself to give him a thorough, personal going-over. Men do change. You may find out why his past has been checkered, and why he will turn into a steady performer in your particular situation.

Training (Item 4). (b) is our choice. The "... maximum freedom for individual initiative and ingenuity . . ." approach in (a) is usually little more than rationalization on the boss's part for no training at all. This "sink or swim" method has long ago proven too expensive for companies in a competitive business.

Alternative (c) sounds like a wise and considerate approach. However, more and more firms are finding it too expensive because—

...trainees do not learn as rapidly or as thoroughly when their assignments are primarily for training purposes;

...the company gets little value from trainees during the training period.

The "baptism under fire" technique (b) has returned to popularity because it is based on the very sound principle of *learning by doing*, and the fact that the trainee is much more highly motivated when he knows that what he does counts. The critical point in this approach is to be sure the trainee *does* receive all the help he needs so that he doesn't fall into costly mistakes and despair.

Personnel Appraisal (Item 5). (a) is our choice. The only catch in this question is that while virtually everyone knows that they should hold regular appraisal interviews, a surprising number of managers just don't seem to get around to it. And when they do, the interview too often fails to get down to cases. It's hard to tell a man where his weaknesses lie. Most of us would rather leave it at: "You're doing a pretty good job, Joe. Try and make it even better next year." This kind of appraisal may be easy, but it doesn't give much help.

The only real appraisal is one that leads to a mutual understanding and acceptance of the subordinate's specific strengths and weaknesses. One method that many managers have found helpful is to let the subordinate do as much of the appraising as he can. The fact that he's telling, rather than being told, lowers his resistance to facing the facts.

Employee Information (Item 6) (b) is our choice. (a) is out because it has been proven time and again that employees who do not understand the relationship between what they are doing and the final product or objective lose their drive to produce. The same thing is true with respect to information about top level problems and planning.: If the employees aren't informed, they feel left out. Once they feel left out, their work invariably drops in quality and quantity to the bare minimum required to hold the job.

(c) is out, too, because it is almost impossible to keep important plans completely secret. What happens is that the news leaks out and usually reaches employees before middle management hears about it. This creates a morale problem in the ranks of management, since people resent learning "top secrets" from their subordinates.

(b), then, is the only feasible alternative and the best one. By deliberately letting people in on advance developments you give them a feeling of "belonging", for which everyone is grateful. Moreover, if this information is passed out through regular channels down the line of management, its distribution will strengthen relationships at each level of the organization.

Delegation of Authority (Item 7). (a) is our choice. This follows the approach recommended on training and distribution of information: The more authority, knowledge and responsibility a manager can give his subordinates, the greater their contribution will be and the faster they will grow. Putting it negatively, there's nothing like authority withheld to make a man feel he's unappreciated, unaccepted and even mistrusted.

Communication (Item 8). (c) is our choice. "You're paid to work, not to talk", is a thing of the past in enlightened managerial circles. Psychologically, humans have a need to communicate with each other. If this need is blocked, frustration will result and this in turn frequently leads to aggressive feelings against the blocking agent. Even if you could take this in your stride, the fact is that people have to communicate in order to work together, and once communication starts, it is impossible to restrict it solely to the work at hand. To try would cost many times more in morale than it could save in talk time.

Allowing communications to run their own course (b) is better than bottling up employees. The manager who does this, however, is missing an excellent chance to turn random conversation into productive thinking about departmental problems. This can be done by deliberately stimulating employee communications in areas where difficulties exist, or where innovations would help.

Keeping Tab (Item 9) (c) is our choice. (a) is out because the information that can be read off performance and expense records often comes too late. With better communications, the manager can correct minor difficulties before they reach the costly stage—at which time they are usually much more difficult to remedy.

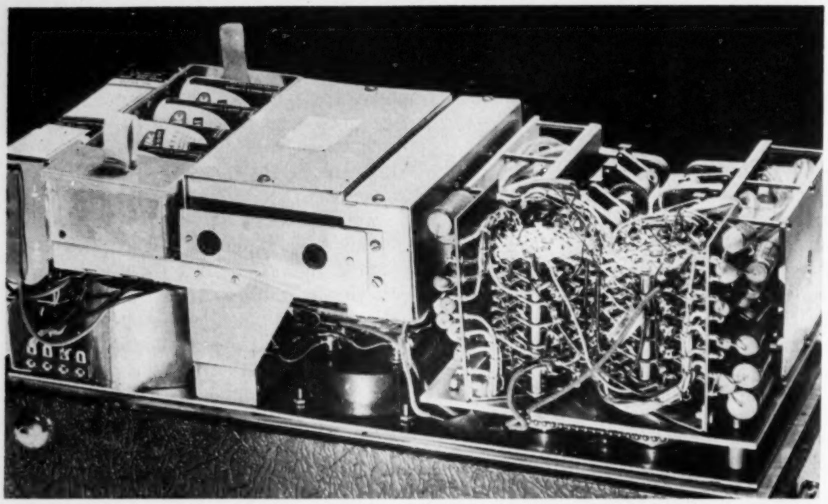
(b) is also out because it is likely to be regarded as the "spy" approach to fact-finding. Actually, it's amazing how many managers who know better slip into this dangerous practice because on the surface it seems easier and more economical than time-consuming departmental meetings. Unfortunately, what may be economy from the manager's point of view looks like the "Crown Prince" approach from his subordinates' standpoint.

Time Management (Item 10). (a) is our choice (but we have yet to do it). (c) is the most common practice. It's also a major contributor to the high-pressure, ulcerated existence of many managers. Men who operate this way may be productive, but if they are it's *in spite of* their undisciplined work habits.

(b) isn't enough, either; the persistent people still get through. Moreover, this means that problems are dealt with on the basis of their owner's aggressiveness rather than actual situational needs.

A good R & D manager could miss one or two of these questions—if he had a good reason for selecting another alternative. But beyond that, you'd better given some serious thought to how you can sharpen your skills as a manager.

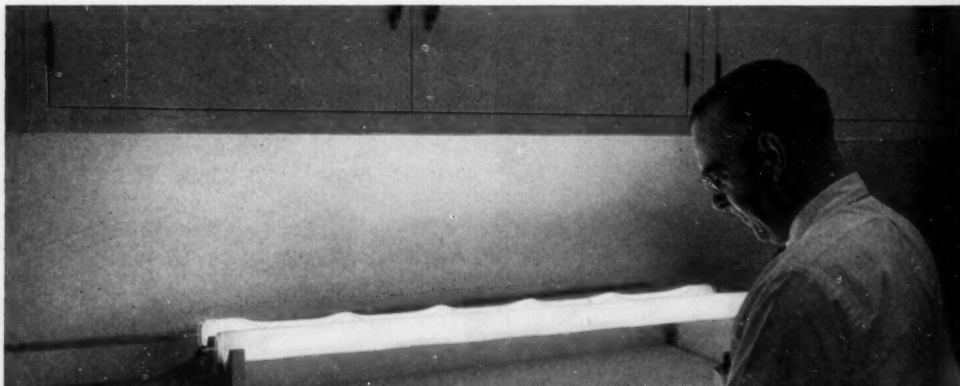
One point that you—as a member of engineering management—will appreciate: the real contributions to the field of management are not being made by those who stress "innate, intuitive" skills in human relations. Instead, it's the more readily definable, measurable and *teachable* practices of systematic management such as careful planning, clear-cut organization, prompt decision and true delegation that are proving to be cf lasting value. END



NOISE ELIMINATION SIMPLIFIED

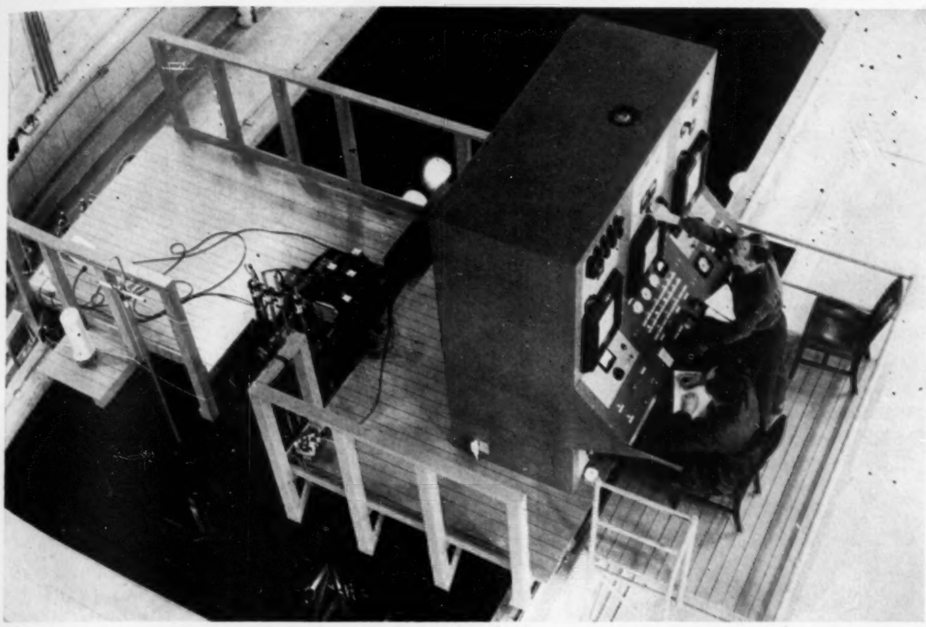
Designers will find the "Soundscope" useful in tracking down the source of objectionable noises in machines under development. Doing the same job as three or four separate instruments, it breaks up the audio range into eight octave bands for analysis up to 150db. Manufactured by Mine Safety Appliances Co., Pittsburgh, Pa., the portable instrument is powered by seven dry cells and incorporates 14 subminiature tubes. The compact construction of the 20-lb device is illustrated above.

prototypes



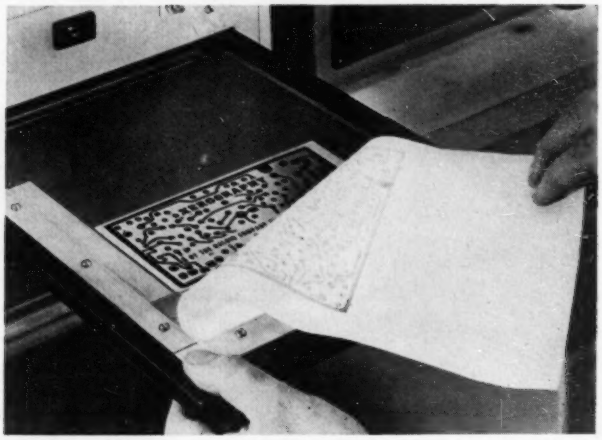
FLUORESCENTS IN THE GROOVE

Running deep grooves along the glass tube doubles light output of fluorescent lamps with no loss in efficiency. The grooves throw more light downwards, an additional advantage. Here GE's Eugene Lemmers of Nela Park, Ohio, who developed these "Power-Groove" lamps, measures their light output. They should be available in the fall for commercial and industrial lighting. Design problem to date has been overcoming loss in efficiency at higher output. The new lamp cross-section decreases losses resulting from "elastic collision" between electrons.



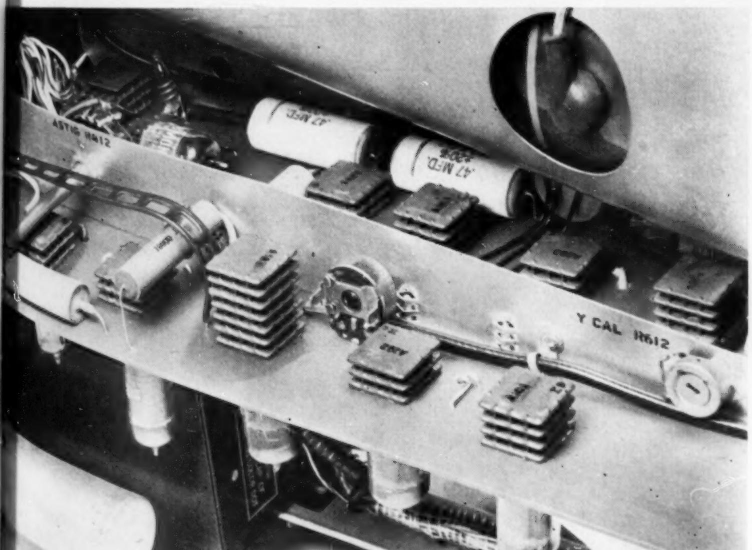
CENTRALIZED CONTROLS FOR RESEARCH REACTOR

Leeds and Northrup engineers designed the centralized instrumentation for Penn State's 100kw "swimming pool" reactor. The system holds power within ±1% of desired output and provides interconnected fast shut-down in case of failure of any part of the system. Careful system design was necessary because uncontrolled power levels can fluctuate by a factor of 10 in fractions of a second.



FASTER PRINTED CIRCUIT PROTOTYPES

Prototype printed circuits can be inexpensively prepared with the aid of xerography, the electrostatic copying method. Here, the circuit configuration is being transferred from a sheet of xerography transfer paper to the copper-clad laminate. According to the Haloid Corporation of Rochester, N. Y., the process is much faster and less expensive than either the photo-resist or silk-screen techniques.



EXPERIMENTAL SCOPE WITH "TINKER TOYS"

After years of experimentation, NBS-developed Tinker Toy modules are finally being incorporated in new electronic designs. This prototype instrument is identical in performance with Du Mont's 350 Oscillograph, which has conventional circuitry. AMF Electronics supplied the various modules used in the experimental instrument.

The Ma

Help for the Busy R & D Manager

More and more R & D executives, faced with severe growing pains, are turning to a little known source of help for their major, nonrecurring administrative ills: the management consultant. This article describes the role of the management consultant in R & D work—scope and type of his services, his method of operation, and an actual case history involving a complex organization problem. . .

Samuel D. Hobbs
Associate Editor

agement Consultant

Today's research and development manager is likely to be expected by his company management to possess just about every managerial skill under the sun: He should be a "human relations" specialist, a genius at organizing his own work and the work of others, technically proficient in at least one and preferably several fields of interest to the firm. In addition, he is expected to have a working knowledge of budgets and control, market research, and the sales and production functions of the business. And if he has a pocketful of patents and an insatiable creative drive, he is a real find.

Company managements, of course, have every right to expect the penultimate in managerial skill and ability, if they are willing to pay the price . . . and if they are willing to shop around long enough. Manifestly, however, no R & D manager can possibly wear all these hats, either simultaneously or separately.

Some top managements fail to realize that the real company hot-seat nowadays is occupied by the hard-working R & D manager. In a techno-economic society, his day-to-day and long range decisions can have a profound effect on the company's future prospects. In the research-based company of tomorrow the most important executive, next to the president, is likely to be the R & D manager.

The fact is that the modern R & D manager is caught in the middle of a tight management squeeze: On the one hand he has been accorded high status and recognition in the management hierarchy. On the other, he is expected to perform what often amounts to a nearly impossible job. To compound the problem, he is usually faced with a burgeoning organization, the necessity for keeping abreast of the latest wrinkles in both technical *and* management sciences, and not nearly enough time to accomplish either objective.

As his organization expands and administrative problems become more complex and time-consuming, the average R & D manager has several courses of action open to him: (1) He can attempt to solve *all* his own problems; (2) he can delegate responsibility to administrative and technical assistants hired for the purpose; (3) he can call on temporary outside help to assist him in solving the major, nonrecurring problems he doesn't have time to tackle himself and do the job properly.

For one reason or another, many a harassed R & D manager has chosen the third alternative. Occasionally the outcome is disappointing; in the vast majority of cases, however, the objective viewpoint and expert knowledge the management consultant is able to bring to bear on the problem results in true achievements.

The Mysterious Consultants

Although management consultants have been a part of the American business scene for at least 50 years, very few businessmen—including R & D managers—know what they do and how they operate.

According to Perrin Stryker, in an article in *Fortune* (May, 1954), "A management consultant . . . . is the man who can tell managers how to manage. The prime virtue of management consultants in the opinion of many executives, is simply their ability to supply management with 'a fresh look at things.' "

Stryker goes on to say that ". . . among the clients of well-established consultant firms, it would appear that about three out of four return for more advice. Practically speaking, then, there is little doubt that management consultants can be useful to management. Yet, for all their good works, they are still among the least known . . . members of corporate society".

One of the reasons why management consultants remain obscure is their own stern code of ethics which frowns on advertising except in an institutional sense. Another can be traced to the natural reluctance of management to release information on consultants' successes. Presumably, an executive who turns to a consultant for help seems to feel that such an action implies a managerial inferiority complex, or it may lead competitors to suspect that the company is in trouble.

Among companies seeking the help of a management consultant, the reverse appears to hold true. It is more frequently the successful companies, rather than the unsuccessful, who retain the management consultant. In general, the more successful executive is more progressive in his thinking, feels that he should continually seek improvements, and is more willing to accept the help that the consultant's specialized experience can bring.

Why the Consultant is Retained

Robert K. Stolz of McKinsey & Company, gives three reasons why R & D managers retain consultants from his firm:

1. The qualified management consultant offers specialized experience on *nonrecurring* laboratory management problems. Thus, the consultant deals frequently with problems that the typical R & D head may face only once in a decade. The consultant can, for example, be helpful in advising on the development of a new organization structure for a laboratory that has grown from infancy to a point where more formal structure is needed. Generally, he has dealt with such problems before and is able to bring

varied experience to bear on them.

2. The consultant can attack on a full-time basis a problem that the research director could work on only sporadically. Thus, with the consultant, the problem gets the attention it deserves. Without him, it may drag on indefinitely.

3. The consultant brings to the research director's problem the "outside point of view". He has no stake in the outcome and can approach the problem with an unbiased, objective point of view that is almost impossible for company personnel to achieve.

McKinsey's Stolz says that working effectively and constructively with a client calls for the consultant to keep two points constantly in mind. First, though he brings specialized experience and the outside point of view to the problem, he recognizes that he has no monopoly on ideas. Many competent people within the client's organization have thought about the problem and have valuable ideas to contribute. The consultant must not only contribute new thinking but should act as a catalyst to stimulate the thinking of client personnel so that they can also contribute to the problem's solution. Of course, in doing so the consultant must be careful to give credit where credit is due and guard against appearing to pass off as his own the ideas of client personnel.

Second, the consultant must recognize that his objective is to motivate the client to act on his recommendations. He cannot accomplish this by simply turning in a written report; he must begin early to help the client understand the problems that exist, their causes, and the reasons for his recommendations.

How the Consultant Works

The typical management consulting firm passes through five phases in performing its work: (1) Obtains and studies the facts pertinent to the problem or situation; (2) analyzes these facts; (3) prepares a program of recommendations for correction or improvement of the weaknesses found; (4) presents and reviews this program with the management involved; and (5) plans and assists in installing the program after it has been accepted. Most management consultants will also "audit" the program after it has been operating for a time, to insure that it is being followed and meeting the needs of the business.

Range of Services

In research and development work, most management consulting firms—particularly the larger ones—are equipped by knowledge and experience to perform the following services for the R & D manager:

- Analysis of product design
- Product engineering
- Process engineering
- Engineering and research administration and project control
- Analysis of new products
- Appraisal of research and development
- Research planning
- Operations research

In addition, some management consultants will assist the R & D manager in locating and hiring key technical or executive personnel, as well as lending a hand in setting up a training, job evaluation, salary administration, or other personnel program.

In the general management area, the management consultant may also prove to be a boon to the busy R & D executive, especially one who is launching a new department or section or who is beset by expansion problems. Such services include furnishing organization surveys, development studies of objectives and policies, and management control and reporting systems, among others. In every case, the management consultant attempts to work with top management as well as with the R & D manager, to insure the necessary top-side support and follow-up.

Type of Personnel

Some management consulting firms are partnerships; some are corporations. The number of professional employees in the average firm has been estimated at 9 or 10, but the larger firm may have 200 or 300 in its organization. Usually there are a small number of partners or principals, with a greater number of staff members and researchers.

Staff members generally have had specialized experience in industry as well as consulting experience. The prime intellectual trait of the management consultant appears to be his ability to analyze and diagnose (hence the "business doctor" tagline which most consultants resent). Ideally, he should be objective in his approach, sincere in his dealings, and tactful with clients.

In research and development work, the question of the management consultant's technical competence sometimes arises. A good rule of thumb seems to be that technically-qualified outside help should be engaged to handle purely technical problems; the R & D manager can choose from scores of consultants specializing in just such matters. Where management problems are concerned, the management consultant can usually do an effective job even though he may not be technically trained; he should, however, have a good knowledge and understanding of research administration problems.

Consultant-Client Arrangements

Typically, the partners or principals of a management consulting firm make the arrangements with client companies. Contracts and formal documents in this business are rare. After an exploratory examination, there may be an exchange of letters, indicating the scope of the work to be performed, the estimated fee for the completed job, and a rough timetable of performance.

When the company decides that the assignment is to be undertaken, one of the partners or principals of the consulting firm is assigned as director of operations. At all points, the work of staff members participating in the assignment is supervised by this partner or principal, and responsibility for actual performance and for relations with the client company is directly centered in him. Throughout the consultant's work, the emphasis is on cooperating closely with the client's personnel and enlisting their support and active assistance.

During the course of the work, periodic conferences are often held to clear major plans with top executives and to guide operating personnel on how to achieve the desired objectives. Frequently, when the work has been completed results are submitted to management in the form of a comprehensive formal report. A follow-up is usually conducted to see if recommendations are working out as expected.

The Question of Costs

Management consultants usually estimate their fees in the form of a minimum-maximum range for the specific assignment, plus traveling and other out-of-pocket expenses. Lump-sum arrangements are rare, for it is almost impossible to tell in advance just what problems will turn up and how much work will be needed to do an adequate job. Estimates are often figured on a per-day rate for the time of staff members involved.

Good management consulting does not come cheap. For one man's services the fee may run from \$75 up to \$350 a day, the most common figure being \$150 a day for a junior staff consultant. Although these fees may seem exorbitant, it should be remembered that a good management consulting firm must hire high-caliber personnel; and they must be held against the competition of highly-paid jobs in business and industry. The acid test is whether the client feels he got his money's worth and calls in the same consultant when the next problem arises.

Selecting a Consultant

The matter of choosing a management consultant is an important one. For one who is unfamiliar with the methods and operations of the consultant, *knowing how* to select the right firm is doubly important.

According to the Association of Consulting Management Engineers, about three out of four management consulting assignments result from the direct recommendation of a satisfied client—one who has used the services of a firm not once but repeatedly.

Whether such a direct recommendation is available or not, the R & D manager in search of a consultant may find it worth while to investigate the performance record of the consultant under consideration.

Any reputable firm, of course, is glad to be investigated as thoroughly as possible. Bank officials and standard investigating agencies should always be checked. It may also be helpful to visit the principals of the firm, to gain an impression of the type of organization it is.

Securing Best Results

A consulting assignment involves commitments on both sides. The starting point is a thorough definition of the problem and a clear understanding between consultant and client as to the procedure that is going to be followed in attacking it. In working with a consultant, the R & D manager should bear in mind that advance discussion *with all company personnel concerned* insures agreement that there is a problem to be solved. In addition, it helps the staff to realize that the consultant is being employed for a definite and useful purpose, and helps to induce cooperation with the consultant when he comes.

Also essential to securing maximum results is a thorough briefing of the consultant on all important aspects of the work, especially in regard to the personalities involved. Having the consultant work closely with a specified individual (or group) within the organization generates understanding of the steps to be taken, and *why they are being taken*, throughout the progress of the assignment.

What the Consultants Say About Their Services

There are nearly as many different types of consultants as there are types of business concerns. According to a 1954 census made by the ACME, 1753 consultant firms operate in the U. S. Of this number, 39 percent are "specialists", i.e., offer only one kind of technique or service, and 61 percent met ACME's own definition of a "management consultant", i.e., offer two or more services.

In general, the R & D manager will be primarily interested in the latter type, chiefly because such a firm can conduct what are broadly termed "studies of organization structure". The reason behind the big interest in this area of the consultant's work, of course, is the tremendous growth of R & D activities in virtually every company, with the accompanying need for organization and reorganization. The trend towards decentralization and diversification in many companies also results in organizational problems in the R & D unit.

The boom in R & D, accompanied by demands for outside help, has created a big new source of business for the management consultant. For example, as a result of its experiences in the past two years, William E. Hill & Company, Inc., New York, has organized a new division specifically devoted to consulting assignments in the research and development management field. According to a spokesman for the firm, "Emphasis in this division is placed on application of increasingly specialized techniques to assist R & D management in planning and organizing operations to meet present and future market requirements".

William E. Hill services three types of companies which they feel can particularly benefit from outside assistance: (1) the company entering fields based on advanced technology for the first time; (2) the company that has experienced rapid growth in several R & D fields; and (3) the company that needs objective appraisal of the commercial aspects of its R & D activities.

This concern makes available a broad range of consulting services to research management including planning of R & D programs, organization planning and administration, evaluation of research projects, and budgeting of expenditures.

In planning, broad but well-defined product fields are selected in which research efforts can be concentrated. In this type of activity, primary emphasis is given to relating the selected fields to overall corporate objectives, and to specialized abilities and skills of the company as a whole. This is particularly needed, the company feels, in "frontier" research fields such as nuclear energy, solid-state electronics, upper air research, and airborne weapons and instrumentation, since markets for these fields are largely developmental and commercial guidance is desirable to reduce the risks involved.

In Hill's opinion, one of the biggest problems facing management today is administration and control of R & D operations and use of sound organizational practices. The firm recently assisted a major oil company in successfully launching an entirely research-based operation, integrating research and management personnel from within the company with newly-recruited technical people from without. Similar assignments have been completed in the electronics, aircraft products, and instrumentation fields.

In the third phase of its work, Hill subjects existing and proposed research projects to specialized techniques of commercial evaluation and to appraisal of their potential in contributing to corporate goals. Some of the company's clients use these technical market research and market development services to assist in relating end-use market requirements to product development.

Hill says that one of the most difficult problems facing R & D management today is the task of establishing and justifying in the eyes of general management the annual research budget. Research budgets must be realistically aligned with overall corporate aims, and management must be helped to an understanding of the proposed research activities in terms of fully developed products, processes—and profitability.

Richardson, Bellows, Henry and Company of New York emphasizes scientific research methods in approaching the personnel and human relations problems of the R & D manager. Pinpointing the effectiveness of proper utilization of research personnel during the much-publicized shortage, RBH conducts a program for clients combining attitude studies to detect points of low motivation; work sampling to detect situations where work now being done by scientific personnel can be reclassified and done by non-scientific personnel; management discussion round-tables which help to develop the plan for reorganizing an R & D department's work; and statistically developed and validated performance report procedures to reduce bias and increase motivation through greater confidence in the review and reward policies.

According to RBH, round-tables in creative thinking, problem solving, and insight development have been used with good effect to increase the fertility of individual thinking and also to develop more concentrated teamwork in solving R & D problems. Team efforts have also been improved through use of a basic method utilizing group therapy principles. This method concentrates on reducing the frustrations and resistances which prevent scientific team-mates from operating at maximum effectiveness in their cooperative attacks on technical problems.

At McKinsey & Company, research and development studies are grouped into three major areas. The first is economic analyses to determine research opportunities. These are primarily studies of marketing and economic factors outside of R & D's sphere, but which have considerable bearing on the nature of the research program. Such studies are aimed at determining what directions the company's research effort should take and the degree of emphasis that should be placed on the different phases of research, in order to conform to market needs, industry problems and technology, the company's position in the industry, and its particular strengths and weaknesses. This type of study also estimates probable costs of research and development work. The results of such economic analysis may show that a company would be wise to discontinue its research effort. On the other hand, the conclusion may be that a company should step up its research effort considerably in terms of the opportunities that are open to it.

Studies of research management methods constitute a second broad area of assistance which McKinsey offers its R & D clients. Such studies are chiefly concentrated on the techniques used by research management in:

- Selection of specific research and development problems to be attacked;

- Coordination of research and development with the functions served, such as

marketing or manufacturing;

- Organization of research work and personnel;
- Budgets and control;
- Methods of communication;
- Methods of motivating research and development personnel, including the use of incentives and the granting of both financial and nonfinancial rewards;
- Techniques of utilizing the creative thinking abilities of research and development personnel more effectively.

Broad diagnostic surveys of the entire research and development activity make up the third major area for study. Such surveys cover many of the aspects mentioned above. The goal of the diagnostic survey is to identify broad areas for improvement. Further studies are usually set up to work out the specific means of capitalizing on the opportunities revealed.

A Case Example

The actual case example below illustrates how a management consulting firm worked with R & D management during an organization study—one of the commoner types of problems the management consultant encounters.

The case in point is an organization study conducted for a medium-sized manufacturing company. The consulting firm had worked with this company on a number of different studies. One day it was called in by the Vice President for Research and Development to discuss a possible study of organization of the R & D activity.

The Vice President pointed out that R & D's basic organizational pattern remained relatively unchanged during the period since World War II even though differences in market needs and technological advances in the industry made considerable change in the nature of the company's R & D effort. For one thing, the size of the exploratory research effort increased considerably, yet some of its key departments and sections were almost buried organizationally. Also, the total R & D activity grew tremendously. While R & D management made several organizational changes from time to time to accommodate this growth few, if any, of these changes were coordinated, and many were simply temporary expedients.

The Vice President also pointed out that communications within the laboratory were becoming increasingly difficult; in some instances research projects involving different sections of the laboratory had been poorly coordinated. Lastly, department heads were overloaded with administrative detail and had almost lost contact with the technical pursuits.

These were the problems that led R & D management to believe the time had come to conduct a study to develop a new plan of organization for the laboratory.

After the initial meeting with the Vice President for Research and Development, the consultant met briefly with the company President to be sure that he agreed to the study and would support any organizational move necessary to increase R & D effectiveness. The consultant then met again with the Vice President for R & D who in the meantime had talked with his immediate staff about the possibility of a study. During this second meeting, objectives were set up for the proposed study; other topics discussed included how the study might be carried forward most smoothly and estimated costs. During this period, there was no commitment on the part of the consultant or the company to go ahead with the study.

The consulting firm then prepared a memorandum outlining its understanding of the reasons for the study, the objectives it should seek to achieve, and the general approach it would follow in carrying it out. The Vice President for R & D circulated this memorandum to the President, to all Vice Presidents, and to his immediate staff. Agreement was then reached to go ahead with the study.

Initial steps in the study included the consultant's getting together with the various laboratory department heads to discuss the study and how it would be carried out; they in turn held meetings with their personnel to inform them of the study. The Research Vice President's administrative assistant was named as liaison representative to work with the consultant in arranging interviews and, in general, to expedite the administrative phases of the study.

The actual fact-finding consisted primarily of interviews with a representative cross-section of laboratory members and of executives in other divisions serviced by the laboratory, principally Sales, Market Research, and Manufacturing. These interviews and analyses of the present and expected work load defined the nature of the work to be done in the future and confirmed difficulties that the present form of organization was encountering. Meetings were held with department heads to reach agreement that these difficulties existed to the extent that change was needed.

As a result of this fact-finding, the consultant considered a wide range of alternative forms of organization and narrowed the choice down to two that appeared best suited to the needs of the laboratory. The pros and cons of each of these two acceptable plans of organization were then spelled out and a series of conferences with laboratory department heads and the Vice president for R & D were held to evaluate the plans. As a result of these meetings, one of the plans was selected.

The plan selected had several features, including:

1. Greater organizational separation for the major types of research carried out in the laboratory, and a clearer pinpointing of responsibility among laboratory management for results in the different areas of research.
2. A regrouping of some of the principal sections of the laboratory. This included raising the organizational status of two sections whose importance in the laboratory had increased considerably in recent years.
3. Better means of coordinating research projects carried out in more than one section of the laboratory.
4. A reduction in the number of levels of supervision involved in project work.

Following selection of the basic plan, the consultant worked with key laboratory personnel to spell out in detail the authorities and responsibilities of jobs in the new form of organization. The consultant also worked out with department heads a program of transition for moving from the old to the new plan. R & D management then named specific individuals to fill the positions set up in the new plan. Following this, laboratory department heads held a series of training meetings to indoctrinate laboratory personnel in the new plan of organization.

In carrying out the study, the consultant kept in fairly constant touch with the Vice President for R & D and his staff. This enabled the consultant to draw on their thinking, keep them informed of progress, and give them preliminary thinking on recommendations.

After completing the major phase of the study, the consultant maintained contact with the laboratory at frequent intervals for a number of months to help work out minor problems as they arose.

Conclusion

The case history above traces, step by step, the procedure through which the consultant and his client arrived at a solution acceptable to both. The method of operation of each consultant may vary, of course, but in general it follows the fact-finding — analysis — recommendation procedure.

While the management consulting activity is a relatively obscure part of our business society, the extent of help it can render in solving major, nonrecurring problems should not be underestimated. At his best, the management consultant's true role is that of supplementing the work of the manager. The skilled and experienced consultant is a link between the expanding body of management knowledge and the executives who are responsible for putting that knowledge to most effective use.

END

(Note: A list of reliable management consulting firms and additional information on the management consulting profession may be obtained by contacting the Association of Consulting Management Engineers, Inc., 347 Madison Ave., New York 17, N. Y.)

TECHNOLOGICAL OMNIBUS:

NBS Has Something for Everyone

From radioactive measurements at 0°K to developing a method for prelubricating ball bearings for long life, the National Bureau of Standards is filling in the holes in our scientific and technological structures. Here's a round-up of the latest work of one of our major R & D organizations.

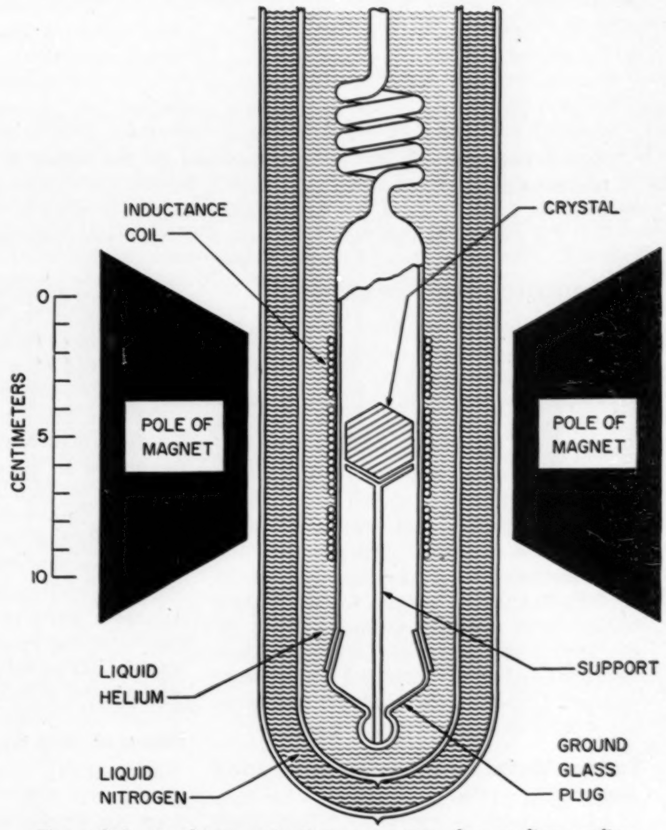
FUNDAMENTAL nuclear research, useful test techniques, new components, special equipment and new computer techniques are some of the latest outpourings of the nation's foremost R & D group. Ranging all over the technological map, the NBS has just made some more rich contributions to our burgeoning science and technology.

LOW-TEMPERATURE RADIOACTIVE STUDY

Working at temperatures within a few thousandths of a degree of absolute zero, NBS scientists have gained information that could lead to an insight into the mechanisms that control decay of radioactive nuclei. The nuclei of three radioactive elements—cerium-139, cerium-141 and neodymium-147—were aligned in their respective crystal lattices. A directional effect can then be observed in the emitted radiation. Drs. E. Ambler and R. D. Hudson of NBS did the experiments in cooperation with Dr. G. M. Temmer of Carnegie Institution of Washington. Initial phases of the work were sponsored by ONR. The apparatus designed to achieve the low temperatures might interest scientists seeking low temperatures for other purposes.

Low-temperature alignment of nuclei promises to provide a new tool for studying nuclear disintegration. The nucleus may be regarded as a magnetic top spinning about an axis. If this spinning magnet is radioactive, the orientation of the spin axis will determine the directions in which the nucleus emits radiation. Normally, when nuclei are randomly oriented, a radioactive specimen emits gamma rays with equal intensity in all directions. However, when the nuclei are aligned, the intensity of gamma radiation varies with angle of emission. Measuring the degree of this directional effect, gives valuable information concerning the decay scheme of the nuclei. For example, the magnetic moment of the nucleus can be determined as well as the changes in angular momentum accompanying the emission.

In the experiments, radioactive nuclei were incorporated into certain inorganic crystals formed by the elements



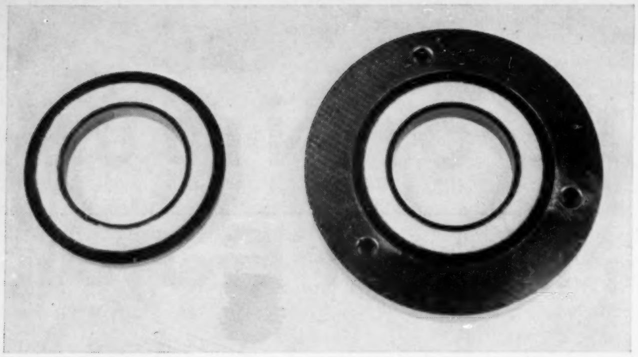
The adiabatic demagnetization apparatus for cooling radioactive crystals to align the nuclei.

studied, which were then cooled. Nuclear alignment was observed by measuring the angular distribution of the intensity of the gamma radiation emitted.

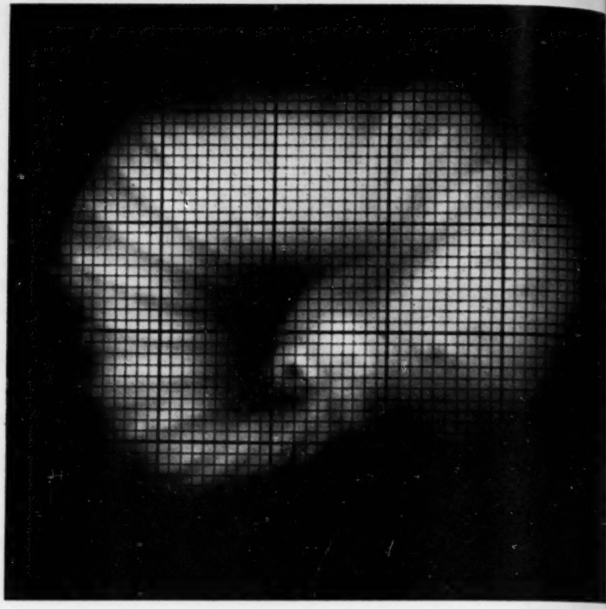
Cool by Adiabatic Demagnetization

Inasmuch as the crystals used were paramagnetic, the necessary low temperatures could be conveniently produced by adiabatic demagnetization. A paramagnetic crystal is first magnetized by a powerful magnet as shown in the drawing at left. The resultant heat of magnetization produced in the crystal is removed from the system. Then when the magnetic field is turned off, the reverse effect occurs, and the temperature of the crystal falls to a very low value.

Work in this general field is continuing on low-temperature methods of polarizing, rather than aligning, nuclei. Stable nuclei can be employed in experiments of this kind, and a larger number of different nuclei can be studied.



Prelubricated ball bearings are lubricated by oils retained by the felt pad at left. The pads are held near the bearing by pairs of the holders at right.



Typical radioactive fallout pattern displayed on the screen of the "Fallout Computer".

PRELUBRICATED BEARINGS

Prelubricated ball bearings are now used extensively in aircraft. Some day even the automobile may be equipped with bearings lubricated once for the life of the car (then you won't have to take the car to the garage for a greasing every 1000 miles). Promising results have been obtained in some trials. Incorporating felt pads to hold the lubricant, the bearings are intended for operation at 10,000 rpm and over the wide temperature range encountered in aircraft. Sponsored in part by the Navy's BuAer, tests covered different types of oils, including synthetics fortified with a variety of additives. Beneficial results were obtained from a viscosity index improver and a mild extreme-pressure additive.

Teflon, Metal or Glass Pads Needed

The ¼-in. thick felts used in the tests became charred at 325°F especially after operating over 1000 hours. For operation above 325°F pads made from other fibers —such as metal, glass or polytetrafluorethylene—might be suitable.

Ball bearings prepacked with grease are not entirely satisfactory especially where speeds and temperatures are high. In aircraft equipment, for example, it is desirable to have bearings that will operate satisfactorily from —65°F to 400°F. Conventional greases are not good enough chiefly because of excessive starting friction at low temperatures and poor stability at high.

In earlier studies, endurance runs were made with several greases in ball bearings operating at 10,000 rpm. At high temperatures, it was found that the greases which performed best were those that adhered to the outer race after being thrown from the path of the balls and then lubricated the bearing by slow bleeding. This behavior suggested that felt rings, saturated with oil, be tried for bleeding oil to the bearings. In effect, the felt would be used instead of a soap or other thickener to supply oil slowly to the bearing.

To test this suggestion, metal holders for felt rings were designed so that such assemblies of holder and felt ring could be fitted to each side of a standard ball bearing. The felt-padded bearings were then subjected to a series of endurance tests in which they were prepacked successively with mineral and synthetic oils. All tests were run at 325°F and 10,000 rpm; and the bearings were mounted in a way similar to that used in the grease tests so that the results might be comparable.

Mineral and Synthetic Oils Studied

Mineral oils used in these tests ranged in viscosity from a transformer oil to an SAE No. 60 motor oil. Some were straight mineral oils; others were of heavy-duty type containing oxidation inhibitors and detergents. Synthetic oils included silicone fluids, polypropylene glycol derivatives containing oxidation inhibitors, and sebacates containing additives. In general, the samples of di(2-ethylhexyl) sebacate containing additives have pour points below –75°F and flash points above 400°F.

With di(2-ethylhexyl) sebacate containing no additive except an oxidation inhibitor the length of the endurance test was only 48 hours. However, with the four samples of this diester containing tricresyl phosphate the length of test before failure was over 1000 hours. One sample, SO-11, is the reference oil given on page three of Military Spec MIL-L-7808. Other samples are essentially this reference oil with other additives designed to increase performance at high temperatures. The four samples of the diester containing tricresyl phosphate were the best tested.

Although the number of tests are too few to be conclusive, the addition of the viscosity index improver to sample SO-11 apparently increased the length of test from 1005 to 1246 hours, and the further addition of a mild extreme-pressure additive (acid phosphate) increased it to 1781 hours. These results are consistent with the expected effect of the additives. In contrast with these results, conventional prelubricated ball bearings filled with a typical prepacking grease lasted only 178, 307, and 330 hours, respectively, in three endurance runs under the same conditions.

Of the various types of oils tested it is believed that the di(2-ethylhexyl) sebacate containing tricresyl phosphate and other appropriate additives is the most promising. In addition to its excellent performance at 325°F, its viscosity characteristics at low temperatures indicate that it would be most suitable for low-torque starting at -65°F.

Trends Indicated

As to the fluids, it appears that a low pour-point mineral oil, such as transformer oil, is not suitable for operation at 325°F because of its high volatility at that temperature. On the other hand, there seems to be no advantage in using an oil higher in viscosity than an SAE 20 grade for lubricating ball bearings at high speed and temperature. Di(2-ethylhexyl) sebacate shows promise of furnishing good longtime lubrication at 325°F, if it contains suitable additives.

A new series of experiments is now under way. These experiments are expected to throw additional light on the above and possible also to yield further results.

ATOMIC FALLOUT COMPUTER

Where the same type of computer prob-

lem arises over and over again, it is often practical to design a special purpose computer that is much simpler, but less flexible, than the big general-purpose computers. A number of these special computers have been constructed already and now the NBS has developed one for calculating geographical fallout patterns of radioactivity from a nuclear explosion.

Given the necessary weather data together with certain information about the bomb, this analog computer will assist in predicting what the distribution and intensity of radioactivity will be on the ground after the bomb has been detonated. Problem solution is displayed on a cathode-ray tube as illustrated, over which a map on a transparent backing can be laid. Radioactive intensity at any ground point up to 500 miles from the explosion can then be measured by the brightness at the corresponding point on the tube screen. The computer was developed for the Weather Bureau and the AEC by H. R. Skramstad and J. H. Wright.

Safety is a prime consideration at the bomb testing grounds. Precautions are taken in advance to prevent radioactive fallout on inhabited areas. Such precautions require information about the bomb as well as an intimate knowledge of the weather pattern, and from these data extensive calculations determine the fallout pattern. In the past, fallout predictions have required the laborious hand calculations of a team of mathematicians for one-half hour or more for each prediction.

Digital computers eliminate most of the manual effort and reduce the calculation time to 15 minutes. However, these high-speed computers are large, permanent and expensive. To provide even faster predictions with portable, relatively inexpensive equipment, NBS developed a special-purpose computer that does not require highly-trained operators. The machine uses electronic analog techniques to complete the computation almost instantly after the data are inserted. Later changes in weather data can easily be inserted as rapidly as the operator can set the appropriate knobs.

Also For Civil Defense

In its use at an atomic proving ground the new computer will provide the test manager with immediate knowledge of the effect of any changes in the winds. For civil defense, the computer can be used in research studies or in case of an actual attack. Forecasting could be expected to help determine and speed up the emergency procedures to be used after a bomb explosion.

TWO COMPUTERS SHARE ONE JOB

The Bureau is more widely known for its work on digital than analog computers like the one discussed above. About two years ago NBS constructed DYSEAC, a mobile computer housed in a large trailer truck. DYSEAC was designed with special input features that enabled it to control other computers in solving problems. This development meant that a giant problem could be solved quickly by a group of computers harnessed together.

Now NBS has announced that its scientists have practiced the coupling together of computers, as envisioned in the original design of DYSEAC. Together with SEAC, the Bureau's older machine, DYSEAC solved a simulated stock transfer problem. Only a limited form of master-slave relationship was demonstrated, because only one of the machines, DYSEAC, had the flexible system features that allow for two programs to be processed at once—interrupting each other as necessary. Several runs of the shared program were sucessfully made, and the "posted" file sections were printed out on a DYSEAC magnetic wire cartridge.

Most general-purpose computers employ a generally compatible digital language, can receive and transmit data in the form of electrical signals via standard communication channels over any desired distance, and can alter the course of processing programs in accordance with new or revised information. It should therefore be possible to interconnect two or more such machines so that they can cooperate on a common task. For example, a versatile large-capacity data-processor at a materiel control center might receive data fed to it automatically by smaller computers located at various supply depts. The supervisory processor (at the center) might so control the system-wide processing that it would accept data from each of its reporting sources in a scheduled sequence but would also be free to accept and handle priority requests for supply action from any of the depots at any time.

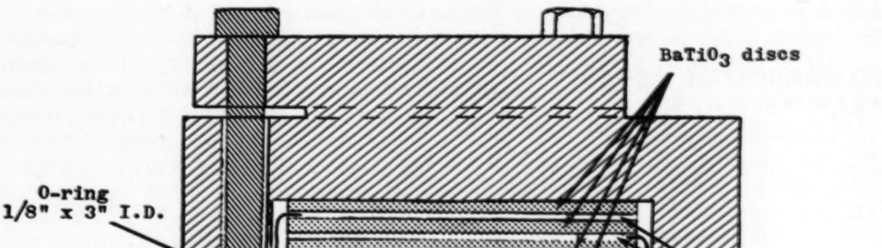
NEW METER FOR SHOCK-VIBRATION TEST

Awareness of the damage that can be done to expensive equipment by shock and vibration in vehicles has let to the development of many devices to test for shock and vibration. Now T. A. Perls and C. W. Kissinger of NBS have designed a new barium titanate velocity meter that can be used on planes and ships. Unlike most instruments used in such tests, the NBS device has a sensitive axis which can be used at any angle without adjustment.

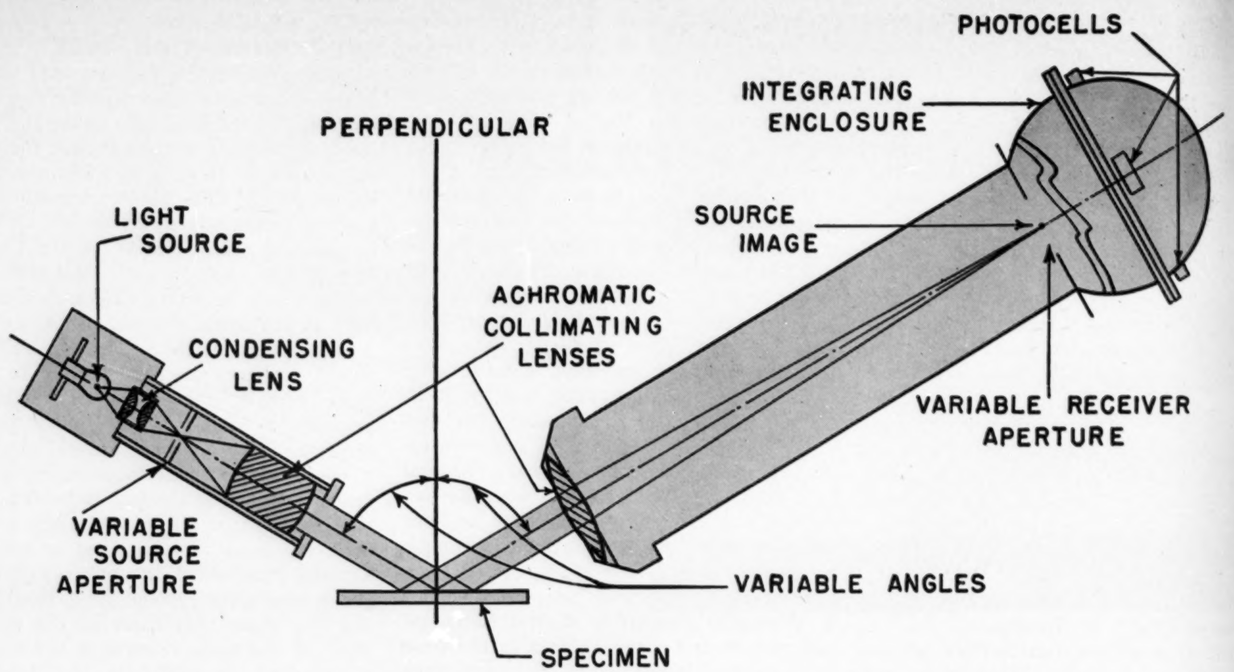
Development of the barium titanate velocity meter was undertaken to overcome certain deficiencies of meters in present use which measure shock velocity directly. These velocity meters consist of a heavy mass spring-mounted to a rigid frame attached to the test structure. When the test structure and frame are accelerated, the mass remains fixed in space for a small fraction of the natural period of the spring-mass system. As a result, during this short time interval, the displacement of the mass relative to the frame is equal (and opposite) to the "absolute" motion of the frame. This relative motion causes a pick-up coil to cut the lines of force of a constant magnetic field, so that a voltage is generated. The voltage is proportional to the relative velocity between mass and frame (or the test structure), and therefore, for a limited time, is proportional to the "absolute velocity" of the frame.

Present Meters Limited

These velocity meters are somewhat limited in operation because of certain inherent defects. They have a limited displacement range, because of the finite travel the sensing element is allowed, and an undesirable low-frequency resonance, typically between 3 and 5cy. Also, it is



Cross-section of the shock-vibration test accelerometer.



Essential elements of the goniophotometer for standardizing specular gloss measurements of enameled porcelain.

necessary to adjust or control the position of the element at the start of the motion. Under some conditions, particularly on a rolling ship, such an adjustment can be made only approximately. Finally, large errors may be introduced in the spring-mass system if the instrument is used with its sensitive axis other than vertical. To overcome these difficulties, the new velocity meter was designed operating on a different principle; this device is essentially an integrating accelerometer.

This accelerometer can conveniently produce shock-damage data which were previously unavailable because of measurement limitations. It is expected that these data will lead eventually to design changes and improvements in the shock-load performance of mobile equipment.

STANDARDIZED GLOSS MEASUREMENTS

Laboratories and chemical plants using enameled porcelain containers and vessels will be interested in the Bureau's development of a standard way of measuring gloss. Gloss measurements have been used principally to evaluate the resistance of high-gloss enamels to abrasion or chemical attack. Intended primarily for application to porcelain enamels, the method establishes sizes and tolerances for the critical geometric dimensions of specular glossmeters. The resulting gloss scale, following a recommendation of the Porcelain Enamel Institute, closely approximates that of the widely used Hunter multipurpose reflectometer.

Usually specimens are measured, before and after attack, on the same instrument in the same lab. The data are useful for determining relative resistance to attack even though a standardized gloss scale is not used. Serious difficulties arise, however, when one attempts to compare readings of nonstandard glossmeters in different labs. A further impulse towards standardization has come in the last few years from the development of porcelain mainly for architectural purposes, these enamels in a wide range of gloss. Used enamels make heavy demands on uniformity of product and matching of components made in different plants.

Specular gloss may be defined as the fraction of light flux reflected in the direction of mirror reflection (the specular direction) when the sample is illuminated by a parallel beam of light. In the case of enamels the angle of incidence (and reflection) is taken as 45°. If the above fraction is multiplied by 1000, the gloss is given in conventional "gloss units". For enamels, then, the specular gloss is the fraction of light energy, in parts per 1000, reflected at 45° when the specimen is illuminated at 45°.

Unfortunately, strictly parallel beams are not obtainable, nor can the light reflected in the specular direction be perfectly separated from that in adjacent directions. NBS studies have shown that disregard of the effects of angular spread among the incident rays (aperture of the source) and among the reflected rays (aperture of the receptor) is largely responsible for the discrepant result obtained with different glossmeters.

SONIC TESTING OF LEATHER

As part of a larger program of research on natural and synthetic high polymers—rubber, plastics, textiles, leathers and papers, NBS has developed a nondestructive sonic method for testing leather. The technique has the advantage of following the effects of aging, chemical treatments and the like on a single specimen. Good correlation between sonic measurements and the results of tensile and breaking elongation tests were obtained. In recent years the use of sonic devices to determine certain mechanical properties of high polymers has become widespread. Industrial users of leather, such as car and gasket makers, should be interested.

A pulse propagation meter is the chief instrument employed to measure and record the speed of a generated 3000cy sound pulse through the leather. The experiments have shown that the velocity of sound in leather varies substantially with changes in chemical and physical structure and, particularly, in fiber orientation. The Army Quartermaster General sponsored this study by J. R. Kanagy and M. Robinson.

Rough measurements were made that showed that the sound attenuation for shoe-upper leather is between 0.1 and 0.2 nepers per cm. For purposes of comparison, the attenuation constants of other polymeric materials were also obtained. It was found that the acoustic attenuation in leather lies midway between that of materials with highly crystalline fibers and that of rubberlike materials.

For the future RESEARCH & ENGINEERING will continue to publish round-ups like this one of the work of the National Bureau of Standards and other outstanding R & D groups.

END

Research Administration

MERRITT A. WILLIAMSON

In last month's column, I promised to discuss the "how" and "who" of communication, since these two elements of the communication art can hardly be separated. Let's take a look at "who" first. In business we can communicate in four ways, one of which is redundant: We can communicate upward, downward, sideways and within. Of course, you spotted immediately that the latter is the redundant means. How many people do you know who are not even in good communication with themselves? Stated differently, how much of the information they transmit do they really understand?

Communicating Upward

Many people seem to have a knack for communicating in one or two of these directions, but are deficient in a third. I think it is rare to find a person with highly developed skill in all three directions. Communicating upward means establishing a rapport with the "boss" so that he understands what you are saying. And, since he understands it, he either takes the advocated action or discusses with you in comprehensible terms his reasons for a different course of action. When he restates your point of view in language more convincing than your own, you know that you have communicated. If action is taken contrary to your recommendation, you will know it is not due to failure of communication.

Undercommunication may result in your supervisor becoming progressively less informed on important areas within his jurisdiction. Great as his trust and confidence in you may be, he will eventually become uneasy since *his* supervisors will question him on these areas.

Overcommunication is also serious since your boss, if he is not careful, will be deciding matters which rightfully fall into your area of responsibility, or you will be wasting his time with items about which he has no concern. Where the fine line between under- and overcommunication should be drawn certainly cannot be stated in any general way. The only guide I know is to study your boss to learn what parts of the job he is particularly interested in and what questions his supervisors are apt to ask him. If he has a financial turn of mind, be prepared to tell him instantly of any departures from the budget. If he is a frustrated scientist, tell him of all your interesting discoveries, get him into the laboratory during a trial run, give technical information and intrigue him with technical problems. If he is a maneuverer, communicate to him the attitudes and feelings of others so that he can take appropriate action.

Study your boss and provide him with the information he needs. He may not be able to spell out in detail what he wants from you, or if he can, he may not wish to; but with the careful study every boss deserves, you should be able to tell whether or not he is satisfied. The best rule I know is not to try just to put yourself in his shoes, but also to try to look at things as he does and to think like him. In short, try to *be* him.

The sixty-four dollar word for this effort is empathy: the imaginative projection of one's own consciousness into another being. If you can develop this, you will instinctively know not only what but how to communicate with him. One cardinal principle of communication is never to let the boss be surprised by being uniformed on any major item in your sphere of activity. Good communication upward strengthens the confidence of your superiors in you, but it does not, of itself, mean that you are doing a good job for the company.

Communication Downward

Communication downward, when properly carried out, insures the loyalty and respect of the men under you. Like communication upward, it is a rapport-inducing device; it is complimentary to your men; it boosts their morale, initiative and will to work. It makes them feel an integral and important part of the organization when they are told what is going on, and when the fate of their suggestions is reported back to them with explanations.

Good downward communication establishes you as a person who can lead. Here again, to be successful, you must have empathy. You must transmit wherever possible what you know will satisfy each person's curiosity, questions and doubts; you cannot sit as a censor who decides that Joe has no need to know and therefore Joe should not know. Whether Joe *needs* to know or not is irrelevant. If Joe *thinks* he needs to know, he will be most unhappy in not knowing. Of course, you have to make sure that what is transmitted to Joe will not be injurious to him or his group's morale. Professor Roethlisberger of the Harvard Business School has written that "the executive should become less interested in what's right and more interested in what works".

Good communications downward insures good communication upward on the part of your subordinates. Sometimes you have to weigh the disturbance caused by giving out certain information against the disturbance caused by employees who surmise rather than know. The decision to communicate depends on the imagination of the staff and their tendency toward jitters. Here, timing is of extreme importance, and the manner of presentation of information may spell the difference between success or failure. Some supervisors play their cards close to their chests, while others lay all the cards on the table. The people you are playing with, their psychology, the general group make-up,

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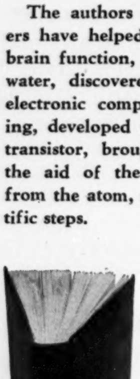

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and the size and importance of the information "kitty," should help to dictate your strategy.

Communicating Sideways

In my opinion the most critical phase of communications exists in the sideways area. This is the willing and voluntary exchange of information by persons of equal status where these persons are known to be contenders for the next promotion; by the very structure of organizations they are pitted against each other as rivals.

The thought of across-the-board communications as an administrative problem does not always occur to the supervisor. If it does, the thought can easily be rationalized away and I am convinced that much of this does happen subconsciously. How is the supervisor to ride herd on persons who fail to pass the word laterally, for reasons of selfish interest, simple neglect, or sheer inconsiderateness? The remedy I suggest for a situation like this is to have carefully spelled-out statements of areas of technical responsibility which have been discussed in meetings where all concerned arrive at a common understanding. The importance of interchange of information within these areas, up, down and across, should be keenly emphasized. Within this framework, any excuse is a feeble one if repeated very often. In my opinion, more people fail to advance because of this deficiency than for any other reason. How can a man be advanced when his supervision is constantly provided with evidence that he will consider matters only from his point of view and from no other? Good communication sideways is one means of advancing up the executive ladder; unfortunately, a great many supervisors fail to realize this.

Communication may be affected through any of the five senses; the most common ways are, of course, through spoken and written media. However, gestures, facial expressions and firmness of handshake are all means of communicating sentiments and attitudes, even when no words are exchanged. You often communicate, then, even when you think you don't. This is an important concept of communication.

How You Communicate

How you communicate depends upon who you are communicating with. To do an effective job, you must study the recipient of your communique. If your boss will not read anything over one page in length, don't submit a three-page letter. If you are writing to non-technical men, don't bore them with tables of data and formulas. If you are asked to write a report on a certain project, find out who is going to receive the report and then beam it toward them in language and concepts they can grasp.

When written for one type of recipient, reports have a habit of being peddled to many others, with the result that criticisms are sometimes leveled against the author. I suspect it is for this reason that most reports contain an abstract; a summary; the conclusions; a summary of experimental procedure for those who want to dig; and an appendix with derivations and tables for those who are deeply interested. The reader can then stop reading at a point where his interest is exceeded. It is important, however, that each part of the report be carefully beamed at the people who would be expected to take appropriate action. One should always be aware that reports are not written for the author.

In the same way, in talking strive for understanding and not just for delivery of well thought-out, high-sounding phrases. We scientists and engineers are very prone to this, so we are told.

Means of Communication

There are many means of communicating. I have before me a list of 48 devices and vehicles for communication. How many of these can you sit down and write off? Are you overlooking some really good methods? Is your standard repertoire limited to only two or three? Does it reach everyone it should reach? Does your communication get stereotyped and stale? How much variety have you introduced in the past year? If enough of you are interested in communications devices that are applicable in research organizations, we can arrange to print a list of them in a future column. In the meantime, I presented a case last month for discussion. The sequel to it follows. Let's have your reaction to this part of the case.

The Servocomp Company (continued)

This is a sequel to the April case in which the heads of the Engineering and Research Departments of Servocomp (the name is fictitious) were charged with the job of reorganizing so that the existing overlap of functions could be eliminated. After a long period of dissention they were able to come up with a plan which was satisfactory to the President of company. This part of the case deals with the communication of the reorganization plans to those affected.

The Research Department had been organized with a Director, an Associate Director and four Division Heads reporting to the Director.

As might well be imagined, during the period when the reorganization was being studied, Research was rife with rumors. Fantastic stories were legion. On Nervous Thursday, the stories hardened into greater authenticity when several anonymous couriers from Engineering carried the tidings that an announcement would be made the following Tuesday. Following is a condensation of the events of the succeeding days:

Friday—Peripheral rumors ceased; a period of watchful waiting ensued.

Monday—Outlying districts were heard from, all strengthening the imminence sug-

gested in Thursday's word. It was apparent that some members of Engineering were given parts of the picture and these parts were beginning to seep through with the usual distortions.

Tuesday—The deadline day came and went with no official word. Several people who had been recently transferred to Research from Engineering were called in by the Director and told where they fitted into the organization. It became evident from what they reported that there were to be two separate divisions, one for Research and one for Development, but there was no information on who had been selected to head these divisions.

Wednesday—Two of the four Division heads were called into the Director's office and apparently were told details on the new organization. The other two were not included. Late in the day the grapevine divulged their names as the two new Division heads, together with the report that one of the remaining Division heads was to be eased into a consulting capacity with no line responsibility.

Thursday—One of the two informed Division heads (the scheduled head of Research) held a divisional meeting and told his men what he knew. This substantiated the rumor that one Division head was being eased out. The Director called in one of the other Division heads and verified the rumor that he would be a consultant but still reporting to him. By now almost everyone knew the set-up. The only person not officially informed was the Division head most affected. The men working for him became most apprehensive.

Friday—The scheduled head of the Development Division called in his staff and told them officially what they already knew, supplying only a few more details. This was given out with the admonition that it be kept confidential. As of five o'clock, the fourth Division head has still received no word and he clearly shows his depression. His men are worried and are trying to pump him for more information. Not one official pronouncement has been issued to this Division as its members depart for a "carefree" week-end.

As Research Director how would you have handled this situation? What principles of sound management were violated? What principles were not invoked that should have been? What about communication? How can the Division head get the Research Director conscious of the morale element? What obligations do they have to do this, if any?

(Please address your replies to Dr. Merritt A. Williamson, c/o Research & Engineering, 77 South Street, Stamford, Conn. Your name will be withheld on request.)

Discussion of Frank Davis' Dilemma

W. A. Mohun, Director of Research for General Abrasive Co., Inc., stated three management principles involved in this case, presented in March: (1) "The prime management principle . . . is that the essential qualification of a supervisor is (to) be able to manage people"; (2) ". . . is that supervisors have a responsibility for training their subordinates and preparing them for promotion"; (3) ". . . . is that unpleasant situations should be faced and definite action taken". According to (1) "Bill Eaton cannot be promoted. Yet tolerating the status quo will only lead to complications and will retard progress". According to (2) "Frank Davis should have started long ago to bring Bill Eaton to see that his irritability will stand in the way of a promotion". But he adds it may not be too late. His solution is for Frank to "call Bill in and put it up to him squarely, but diplomatically, that his failure to manage himself prevents his promotion".

D. B. Keyes of Arthur D. Little, Inc., takes essentially the same approach advocated by W. A. Mohun. In discussing a situation quite similar to this which he knew about, he writes: "'Frank' had a heart-to-heart talk with his 'Bill Eaton' and told him there was only one way to solve the problem. He said, 'Bill, it is up to you to persuade someone in the Section to show you how to handle this project and to act as your guide or advisor. You are on trial as a project leader. If you make good, fine, if not, we will still keep you in research.'

"The result was that Bill found out he did not want to be a project leader—too much grief trying to handle men. Furthermore, Bill really got to know other men in the Section much better, and they in turn began to understand him better.

"'Frank' admitted to me the results were not perfect, but he did gain by this experiment." The important difference is, of course, that regardless of the outcome, Bill is still a member of the company.

Eugene J. Caron, Manager, Television Engineering Dept. of Radio Condenser Co., concurs with Mohun's point (2) and feels that Frank Davis "might have avoided the situation". He too recommends that Frank take Bill aside and try to help him realize his own weaknesses which, once recognized, "he will, in all likelihood, take steps to correct . . ."

L. Pessel of Wyndmoor, Pa., comments: "The feeling of Bill's own men towards him are not unusual when a mediocre crew discovers in its midst a mind of creative originality and uncompromising drive. Also, Bill's acerbity might at least be partly due to stifled ambition and a feeling of being kept at an undeservingly low level. Such aggressive mannerism is often the reaction of an inferiority complex. If Bill gets his promotion, his manners are bound to become more mellow as a consequence of relaxed tensions and a sense of dignity produced by the elevation of his position."

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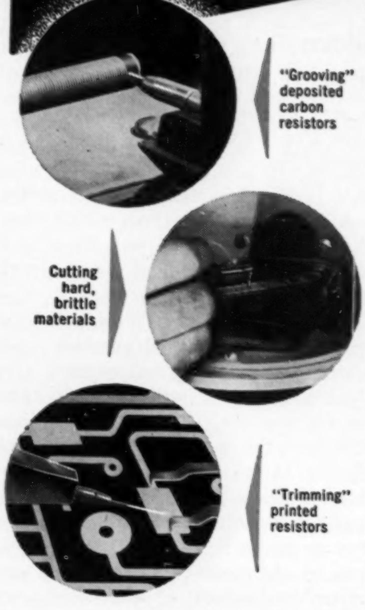

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R/E views the books

Modern Gas Analysis

by Paul W. Mullen

Reviewed by Dr. R. C. Vickery, Section Head of Chemistry, Horizons, Inc.

This is No. 6 in the excellent series of manuals prepared by these publishers on methods of laboratory evaluation and is generally in good conformity with previous members of the series.

Although this book is "designed to give the student or industrial chemist . . . an acquaintance with the entire field of gas analysis", I feel it will generally find a home on the shelves of a large library, rather than the more austere book shelves of a student or industrial chemist. But it will nevertheless frequently be referred to.

It is conceivable that the main fault with this monograph lies in the conciseness required by its mode of presentation and a more expansive book, of which the present volume might well be a draft, would be of inestimable value. There is undoubtedly room for a good book in this field, but the last sentence of the introduction is rather abnegatory — *"Hempel's Gasanalytische Methoden,* published in 1900, outlines gas absorbents, apparatus, and methods of analysis of gas mixtures, all of which, to some extent, are still standard in gas analytical work." The literal interpretation is therefore that gas analysis has not advanced very far in over half a century. However, since approximately half of the book relates to instrumental methods of gas analysis, it may be interpreted that the emphasis, even in this field, is now on physical rather than chemical attributes.

Illustration of this book is, in general, excellent, although the great use of blocks from catalogues of scientific supply houses diminished my enjoyment of the text.

Possibly because of the conciseness previously referred to, I looked in vain for a reference to the *Reisch* test—that "die-hard" stand-by of industrial gas analysis, currently employed by what must be every sulphuric acid plant in the world. Similarly, in the chapter on measurement of P-V-T parameters the author states that for every use, gauges must be calibrated empirically for each gas. Although fundamentally correct, few laboratories adhere to this practice and, in many cases, a different gauge for each gas used is rare; an effective section could therefore have included how a meter for one gas could be calibrated for another by calculation.

Again, blood is said to be the best reagent for carbon monoxide, yet only seven lines of print are apportioned to it, while the use of cuprous chloride fills nearly two pages. While conceding the greater use of cuprous chloride, I feel the author could have added another four or five lines explaining why blood is relegated in favor of cuprous chloride.

These few omissions detract little from the value of this manual which, in this era of science and technology, presents in a concise form the fundamentals of gas analysis techniques and thereby fulfills the aims for which it was produced.

Interscience Publishers, Inc., New York, N. Y. 354 pages, $5.50.

Introduction to Electronic Analogue Computers

By C. A. A. Wass

Reviewed by C. Earle Theall, Jr., Engineer, CGS Laboratories, Inc.

With analogue computers increasing in use, knowledge of analogue techniques will become, for many engineers, a necessary supplement to knowledge of system analysis. Simplicity of programming, the ability to stimulate complicated systems, and the ease of changing parameters in a set up problem are valuable features of analogue computing. Also, many large systems use computing circuitry to perform mathematical work within the framework of the overall system functions.

Mr. Wass describes electronic analogue techniques interestingly and clearly. At the same time he presents material of sufficient range and detail to be of use in the laboratory. Readers will appreciate the simple, direct, yet adequate style and the absence of coined words and cumbersome constructions that occasionally appear in technical writing.

After an introductory chapter the book divides evenly between component design and computer applications with five chapters devoted to each. Amplifiers, function generators, multipliers and other non-linear components are shown. The chapters on amplifiers describe the effect of grid current on drift and the chopper stabilization method of overcoming it. Brief mention is made of drift due to filament voltage and plate supply voltage variations. Circuits are shown and described for amplifiers of all states of complexity, from single tube amplifiers to multi-tube, chopper stabilized amplifiers. The uses of amplifiers as integrating, summing and multiplying components are described, showing methods of setting initial conditions and predicting the gains required for given accuracies. The control of feedback phase is mentioned as a design problem as well as one reason for avoiding the use of the amplifier as a differentiating component.

Discussions of analogue applications include summaries of an automotive suspension problem and an aircraft flight problem. Also discussed are methods of setting up simulators, simulators for nonlinear problems, and methods for adjusting and testing components.

The book does not cover all the detailed information useful in circuit design and computer use. Mr. Wass says ". . . the aim has been to state basic principles rather than to describe detailed designs and design methods". The book is consistent with this aim; it is truly an "Introduction", not a handbook. A short reference list guides the reader to thirty sources on differential analyzers, simulators and computer components and toward well known texts in related fields.

McGraw-Hill Book Co., Inc., New York, N. Y., and Pergamon Press Ltd., London. 237 pages, $6.50.

Vapor Plating, The Formation of Coatings by Vapor-Deposition Techniques

By C. F. Powell, I. E. Campbell and B. W. Gonset

Reviewed by Andre de Rudnay, Senior Engineering Scientist, College of Engineering, New York University

The general term "Vapor Plating" includes three distinct techniques, all of them relative newcomers to the coating field: the purely physical method of nonreactive vacuum evaporation and sputtering; the physico-chemical method of vacuum evaporation and sputtering performed in the presence of reactive gases; and the purely chemical method of thermal decomposition or reduction of a gaseous compound at the heated surface of a target.

This book, sponsored by the Electrochemical Society, Inc., is solely concerned with the last mentioned method, and lists some 150 metals, semi-conductors, alloys, hard metals and oxides that can be de-

posited, on a large number of metallic and dielectric targets, by one or several varieties of the chemical vapor plating techniques. Suitable deposition methods are described for each type of coating, and the description includes not only the authors' own developments and experience, much of it acquired in connection with Project RAND, but also a critical survey of procedures already outlined in the literature.

The authors' main concern was evidently a comprehensive investigation of heat-and-corrosion-resistant coatings for combustion-and- exhaust-chambers, gas turbine blades, etc. However, they emphasize that the vapor plating techniques might, and in some cases already do, find application in various fields of chemical, electronic, mechanical, metallurgical and optical engineering. Typical enclosed-type batch-coating and continuous-flow apparatus are described in detail, together with a flow chart for vapor deposition by hydrogen reduction. The Schott-pistol for free-space oxide coating of optical glasses is briefly mentioned.

Much of the information contained in the book, particularly the summaries on coating characteristics, coating adhesion and effect of deposition temperature on properties of coatings, are also of great value to those interested in vacuum plating.

Altogether this is an excellent book, a much needed, concise and comprehensive treatment of the present status of the art of chemical vapor plating. It is highly commended to engineers and research workers in practically every field of engineering.

John Wiley & Sons, Inc., New York, N. Y. 158 pages, $5.50.

Linear Feedback Analysis

BY J. G. THOMASON, B.SC.

Reviewed by Jack Johnstone, Electronics Engineer, CGS Laboratories, Inc.

Linear Feedback Analysis is a textbook for the practicing engineer containing much useful electronic circuit information and few extensive mathematical proofs. Vacuum tube circuits and associated passive electrical networks form the chief subjects of analysis. A basic understanding of the calculus and a knowledge of vacuum tube theory is assumed by the author.

The introductory chapter deals with steady-state circuit analysis and employs the methods of nodal and mesh analysis and determinants in the solutions of simple linear networks. In the following two chapters the concept of the Laplace Transform and the use of poles and zeros in determining network stability are introduced. The author wisely omits the rigorous mathematical proofs frequently encountered in a presentation of the Laplace Transform. Engineers will appreciate the direct treatment of simple feedback circuits and amplifying stage design in chapters four and five. Illustrative examples include series and shunt feedback, the cathode follower, and direct coupled amplifiers. Recourse to idealized circuitry is avoided.

Devoted to the mathematics of the complex variable and Nyquist's Criterion, the sixth chapter provides a second means for determining the stability of a system. This is applied to transfer functions too complex to be solved readily by the simple algebraic techniques outlined in the initial chapters. A third method follows in which the phase shift and gain are derived from the transfer function. The effects of circuit parameters upon the response of several simple passive networks are analysed by this technique. To conclude the analytical portion of the book, the author correlates the three methods of determining amplifier stability and outlines the practical methods of feedback amplifier stabilization.

The last quarter of the book is of an illustrative nature, analysing some common electronic circuits. Examples include various types of feedback amplifiers, feedback integrators and differentiators (including the Miller sweep circuit), and stabilized power supplies.

Illustrative portions of the book, particularly this last section, are well written and very clear. Many circuit "bugs" commonly regarded as trivial in less practical texts are brought to light. The author shows an appreciation for the economic aspects of engineering and presents alternative circuits for use where design requirements are not stringent

The analytical chapters have a weakness common to many scientific works: that is, the failure to follow a mathematical proof with a clear statement of the results and a set of rules by which theory may be applied to real problems. This weakness limits the utility of a well-written text for the engineer interested in practical application of the theory.

McGraw-Hill Book Co., New York, 355 pages, $8.50.

Economic Geography of Industrial Materials

BY KENNETH DENBIGH

Reviewed by John Rivoire, Manager of Market Research, Westvaco Mineral Products Div., Food Machinery & Chemical Corp.

The method employed in this book is that of the symposium. Each of the 20 chapters is written by someone closely associated with the industry it covers: the chapter on petroleum, for example, is written by John W. Frey of the American Petroleum Institute; and the chapter on transportation in the introductory section by D. P. Locklin of the University of Illinois, author of many books and papers in the field of transportation economics. Most of the contributors are associated with industrial concerns or with trade associations rather than academic institutions or government agencies.

Apart from the first general section on resources and transportation which includes editor Carlson's introductory chapter on populations and their resources and Locklin's chapter on transportation, the book is divided into four parts. The first of these deals with "Fuel and Power for Industry" and contains three chapters, one each on coal, petroleum and electric power. The second (part III of the book) covers "Products from Minerals". Its chapters deal consecutively with iron and steel, aluminum, copper, titanium, phosphate rock, sulfuric acid, lead and glass. These nine chapters form the largest of the four industry sections.

Part IV deals with "Natural and Synthetic Products", not a notably clear heading. This section has six chapters covering forest products, pulp and paper, textile raw materials, the textile industry, synthetic organic chemicals and the cottonseed processing industry. The fifth and last part of the book deals with agricultural and food products.

This book is somewhat disappointing for these reasons: some of the individual sections are quite good, but others sketchy, and there is little uniformity between them; it presents no general scheme which shows how the different resources and their products fit into industry patterns, nor does it present a scheme of analysis. Some of the industry sections are unduly sketchy—for example, it is hardly possible to give an adequate treatment of the synthetic organic chemical industry in the 11 pages allotted. There are some puzzling gaps also. Nothing, for example, is mentioned of the rubber industry even though it is practically the sole user of a very large and important industrial material. The building materials, non-metallic minerals and minor metals also seem to have been slighted. Finally, one section, that on electric power, presents a rather one-sided picture and some subtle bias.

On the positive side, this volume should provide a handy reference to the general features of some industries. The scope is purposely limited to industrial products and further limited by the omissions and shortcomings noted above, but within those limitations provides good pictures of some of these industries. The chapters on textiles and textile materials and on petroleum and aluminum are especially good. The bibliographies at the end of each chapter are helpful, but these are not uniform in quality, and in some cases are omitted.

The value of this book to R & D men will vary with individual needs. The specialist in one area will not find anything in it which will add to his knowledge of his own specialty, but he should be able to get some valuable background information on areas unfamiliar to him.

Reinhold Publishing Corporation, 473 pages, $12.50.

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D. C., unless another source is stated.

Wool/Synthetic Blends

Because of processing difficulties in velour fabrics of wool/synthetic blends, the Air Force has decided to continue to use only 100 percent wool for overcoat material. Tests on a group of 30 velour overcoats of wool blended with synthetics in percentages of 10, 20, 30, 40, 50 and 60 percent were studied. As the percentage of synthetic was increased in the blend the difficulties at the fulling process increased and it became more difficult to obtain desired color and finish. However, when varying degrees of synthetics were used an increase in breaking strength was noted. Also noted was a general increase in flat and flex abrasion resistance.

Evaluation of Experimental Wool and Synthetic Blends in Air Force Velour Overcoat Material, *PB 111884, 37 pages, $1.25.*

Displacement Pump

Design and construction of a new type positive displacement pump for accurate metering of liquids is discussed in this report. It has been applied successfully to obtain constant flows, liquid levels, automatic proportioning, pilot studies of automatic water chemical treatment, etc. The report describes in detail the pump's construction, uses and limitation, and contains photographs of the pump and its components.

A Positive Displacement Pump for Accurate Metering of Liquids, *PB 111851, 11 pages, $0.50.*

Research Information

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Electrodeposition of Titanium, *PB 111876, 11 pages, $0.50.*

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